Thus, we can draw the following conclusions:

Methods of teaching mean the joint work of the teacher and students to achieve their educational goals. They are one of the tools and techniques of educationally purposeful interaction between teacher and students.

REFERENCES

1. Pedagogika: Ucheb. posobie dlja stud. ped. vuzov i ped. kolledzhej / Pod red. P.I. Pidkasistogo. – M.: Pedagogicheskoe obshhestvo Rossii, 2006.
2. Pedagogika: Uchebnik dlja stud. ped. vuzov i ped. kolledzhej / Pod red. P.I. Pidkasistogo. – M., 2002.
3. Slastenin V.A. Obshhaja pedagogika: Ucheb. posobie dlja stud. vyssh. ucheb. zavedenij / Pod red. V. A. Slastenina: M., 2005.
4. Hutorskoj A.V. Sovremennaja didaktika: Uchebnik dlja vuzov. – SPb: Piter, 2001.

INVESTIGATION OF WATER DROP AT FREE-FALL ON A HEATED SUBSTRATE

K. A. Batishcheva, E. G. Orlova, D. V. Feoktistov

Tomsk Polytechnic University

Droplet free-falling process and further spreading on a solid substrate are the most interesting directions of studying for many scientists in the world. However, simultaneous investigation of these two processes is quite difficult problem.

Spreading of liquid drop on solid surface is the most important process when studying of wetting. Numerical and experimental investigations of liquid drop spreading on solid surface [1-4] have allowed establishing some important laws. However currently there is a lack of extended theory of wetting. There are no full published results of experimental studies of liquid drop spreading when it free-falls on a heated surface. It should be noted that investigation of mechanism of drops impingement with a heated substrate involves not only thermal processes, but also the physical and dynamic in particular spreading. Studies with using high-speed cameras have been made relatively recently [4].

Nowadays there are no models allowing making prognostic assessment of changes in drop shape in terms of its free-falling, depending on the conditions of drop formation on dispenser. Progress in this area of science is constrained by the lack of comprehensive experimental studies using high-speed cameras.

The purpose of the work is conducting a series of experiments for studying the behavior of water drop at free-falling on a heated substrate and further spreading.

A scheme of experimental setup is shown in Fig.1.

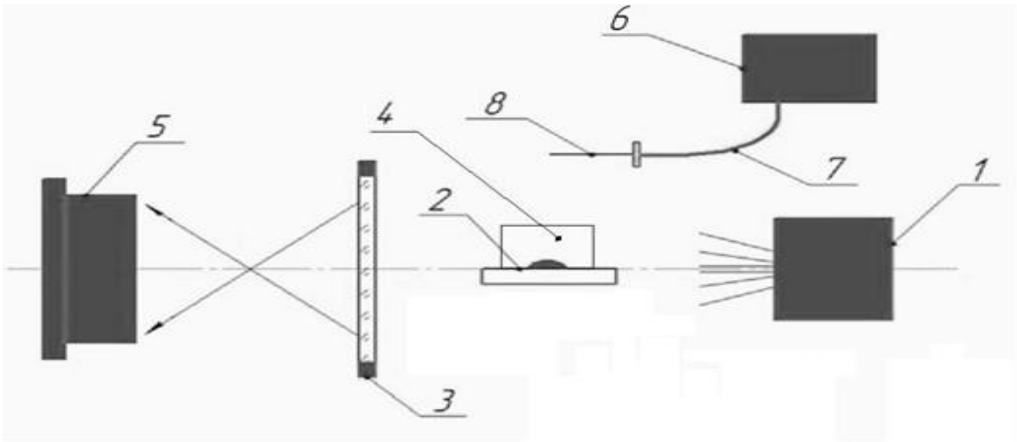


Fig. 1 – A scheme of experimental setup:
1 – light source; 2– substrate; 3 – condensing lens; 4– transparent box; 5– high-speed camera; 6 – electronic unit pump; 7 – pipe of experimental liquid supply; 8 – dispenser for drop formation.

The main elements of experimental setup are light source 1, substrate 2, high-speed camera 5 and dispenser 8 for drop formation.

The transparent box 4 made of glass is destined for reducing of the impact of environmental factors, such as a movement of air mass, differential temperature in the room. The opening from top is needed for unhindered drops free-falling, side openings are needed for path of parallel rays from the light source 1 to the camera lens 5.

As test substrate we use flexible copper disk (Fig.2) of thickness 4 mm and diameter 54 mm.

Fig. 2 – Flexible copper disk

The flow rate of water supply through pipe *7* to dispenser *8* is controlled by electronic unit pump *6* (Cole-Parmer Touch Screen). This pump is shown in Fig.3. Electronic unit pump allows to set necessary water flow rate and drop volume.

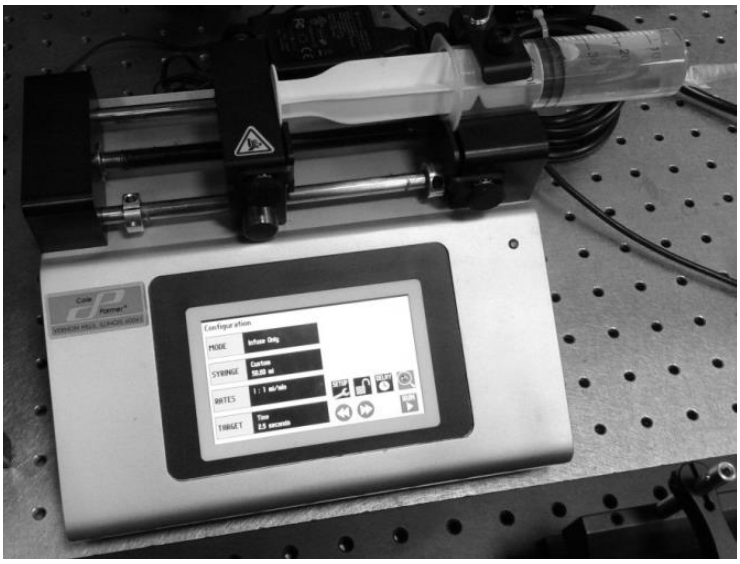
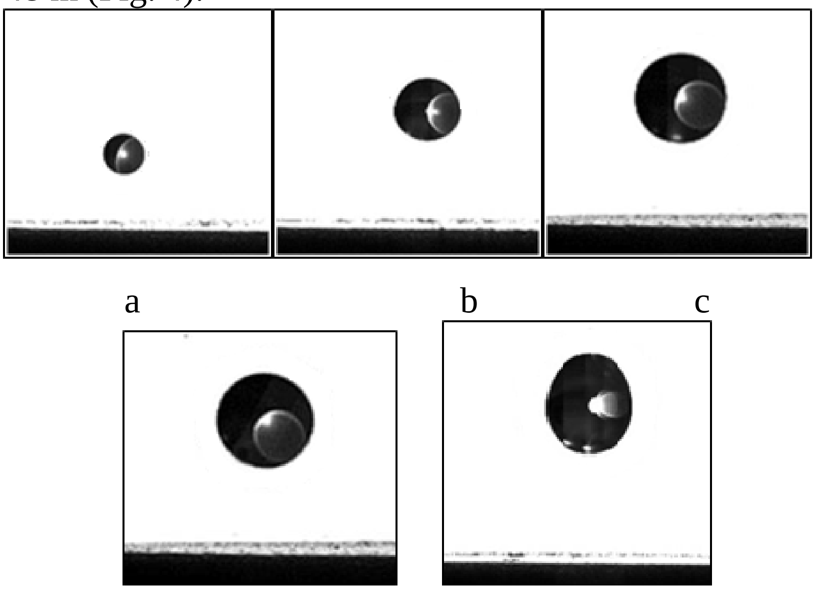


Fig. 3 – Electronic unit pump Cole-Parmer Touch Screen

Shadow method was used to record drop spreading process [5-7]. The light source 1 produces a beam of plane-parallel light illuminating the drop on the substrate 2. The objective of camera 5 and the condensing lens 3 are used to project the image on the camera sensor.

Drops have been dosed to the surface from a height of 50 – 300 mm with step of height change of 50 mm. The dosing devices are the needles with different inside diameters for formation of drops with volumes: 0.006 ml; 0.012 ml; 0.018 ml; 0.023 ml; 0.048 m (Fig. 4).



a b c

d e

Fig. 4 – Drop free-falling with volumes: a) V=0.006 ml; b) V=0.012 ml; c) V=0.018 ml; d) V=0.023 ml; e) V=0.048 ml.

It was found that drop volume is the factor affecting the geometrical shape of drop in terms of its free-falling. Drops with volume up to 0.023ml don't change spheroidal shape at free-falling. Drop with volume 0.048 ml changes geometrical form at random (Fig. 5).

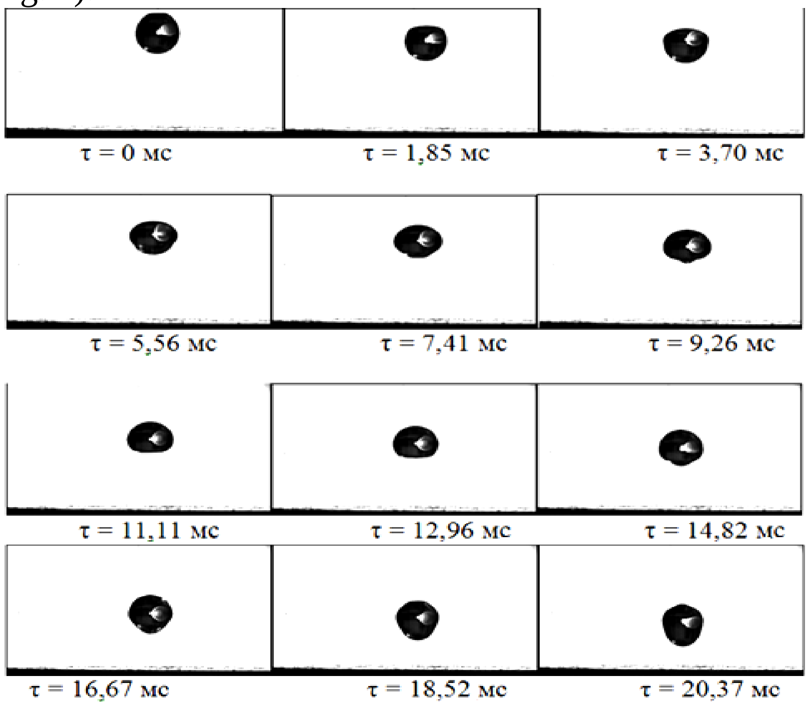


Fig. 5 – Snapshots of the falling drops process with volume V = 0,048ml

It was found that velocity of droplets extrusion with a syringe dispenser affects droplet shape in terms of its free-falling. It should be noted that drop with small sizes (0.006 ml) at velocity of formation of greater than 0.1 ml/sec changes geometric shape while falling.

The main factor affecting geometrical shape of drop is the drop volume at low velocities of droplets extrusion with a syringe dispenser (up to 0.1ml/sec).

Geometric characteristics of falling drops were fixed by indirect method (at video processing). The experimental data are summarized in Table 1.

Table 1.

Geometric characteristics of drops at different volume of dosing

Volume of drop dosing, ml	0.006	0.012	0.018	0.023	0.048
Drop diameter at free-falling, mm	2.24	2.88	3.25	3.55	4.5
Drop mass, mg	5.84	12.44	17.97	23.41	47.69
Drop velocity when approaching substrate from height of 300mm, m/sec	2.45	2.45	2.45	2.45	2.45

It was found, that condition of drop formation on dispenser (in particular liquid flow rate) affects geometric form of drop in terms of its free-falling.

Also, the drop diameter has been registered according to spreading process on substrate. Spreading rate of liquid droplet we define as:

$$V = \frac{D_1 - D_2}{t}, \; mm/s,$$

where D_1 – drop diameter, mm; D_2 – drop diameter recorded in the previous time step , mm; t = 0,0002 – time step, s.

Figure 6 demonstrates variation of liquid drop spreading rate in time.

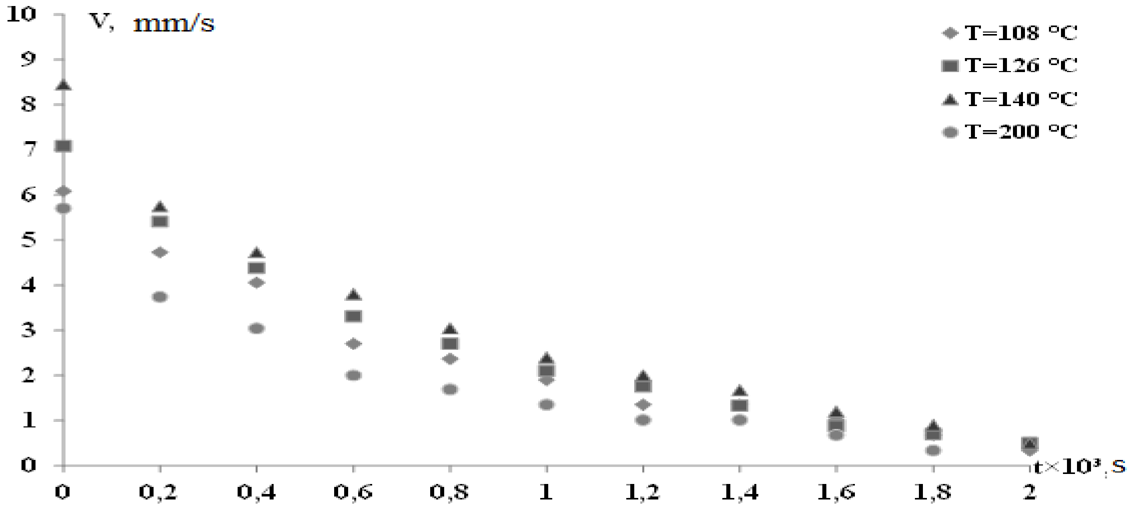


Fig. 6 – Liquid drop spreading rate at substrate temperatures 108°C; 126°C; 140°C; 200°C.

According to the analysis of Fig. 6 the curve of liquid drop spreading rate changes exponentially at range of temperature variation 60–200°C. At the initial time, when liquid drop contacts with the heated surface it spreads and contact diameter reaches maximum value under the force of inertia. Next, the attractive forces of the molecules contribute to its contraction to equilibrium. It should be noted that the spreading rate after time point 0,002s assumes constant values V = 0.3 ÷ 0.5 m/s and does not depend on the surface temperature.

Also it has been found that liquid drop spreading rate does not depend on the surface temperature at temperatures up to 108°C. Continued heating results in an increased liquid drop spreading rate and reaches a maximum values at temperature of 140°C. By heating the surface over 140°C the decreasing of spreading rate is occurred. Studying the behavior of water drop at free-fall on a heated substrate and further spreading was conducted.

The main obtained results are:

- The velocity of droplets extrusion with a syringe dispenser affects droplet shape in terms of its free-falling.
- The drop volume at low velocities of droplets extrusion with a syringe dispenser (up to 0.1ml/sec) affects geometrical shape of drop.

- The curve of liquid drop spreading rate changes exponentially at range of temperature variation 60 – 200°C.
- The spreading rate after time point 0,002s assumes constant values V = 0.3 ÷ 0.5 m/s and does not depend on the surface temperature.
- At surface temperatures up to 108°C liquid drop spreading rate does not depend on the surface temperature.

These results can be used for predictive modeling of the processes occurring in the high-intensity heat exchangers, pneumatic, spray, rotary, drum, spiral dryer, in heat engines, in the schemes of inkjet printing, etc.

REFERENCES

1. Avakimyan, N. N., Vasiliev, N. I., Guguchkin, V. V. Eksperimentalnoe issledovanie teplovogo vzaimodeystviya osazhdayuschihsya kapel s nagretoy poverhnostyu // IV Minsk International Forum on Heat and Mass Transfer. – 2000. – V 10. – P. 315-317.
2. Bartolo, D., Josserand, C., Bonn, D. Singular Jets and Bubbles in Drop Impact // Phys. Rev. E. – 2006. – Vol. 62. – P. 756-765.
3. Borodin, S. A. Issledovanie processa rastekanija kapli zhidkosti, nanosimoj na poverhnost' podlozhki // Computer optics. – 2005. – № 28. – P. 66-68.
4. Uryukov, B. A., Belik, V. D., Tkachenko, G. V. An approximate model of the dynamics and heat transfer of an impact cylindrical ideal liquid jet // Journal of Engineering Physics and Thermophysics. – 2012. – № 2. – P. 299-304.
5. Gatapova, E. Ya., Semenov, A. A., Zaitsev, D. V., Kabov, O. A. Colloids and Surfaces A: Physicochem. Eng. Aspects. – 2014. – С. 441- 445.
6. Orlova, E., Kuznetsov, G., Feoktistov, D. (2014). The evaporation of the water-sodium chlorides solution droplets on the heated substrate // EPJ Web of Conferences, V 76, 012039.
7. Gubarev, V. Y., Arzamastcev, A. G. Evaporation from Drop on the Hot Surface // Thermal Processes in Engineering. – 2010. – Vol. 2. – P. 63-66.

ИСПОЛЬЗОВАНИЕ МЕТОДА ПРОЕКТОВ ДЛЯ ПРОФЕССИОНАЛЬНОГО САМООПРЕДЕЛЕНИЯ СТАРШЕКЛАССНИКОВ НА УРОКАХ АНГЛИЙСКОГО ЯЗЫКА

И. И. Блохина, О. В. Шумкова
Новосибирский государственный университет

На данный момент существует серьезная проблема формирования профессионального самоопределения на различных стадиях развития личности. Одной из вопросов профессионального самоопределения личности является выбор учеником направления будущего профессионального