EFFECT OF INITIAL LIQUID PARAMETERS ON JET DISINTEGRATION

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We study the dependence of the length of the continuous portion of a jet on the nozzle diameter for different initial pressure and temperature of the water being sprayed. A schematic of the experimental setup is shown and its operating principle is described.

We find that with increase of the temperature of the liquid being sprayed the length of the continuous part of the jet decreases, while this length increases with increase of the pressure (up to 6 atm). When spraying superheated water nearly complete disintegration of the jet is achieved at a temperature close to the boiling point of the water. It is also found that in the low pressure range (2-5 atm gage), regardless of the parameters of the water being sprayed, the maximal length of the continuous part of the jet is obtained for a nozzle diameter d = 1.5-1.8 mm at temperatures of 15-120°C and for d = 0.8-1.2 mm at temperatures >120°C.

The nature of the disintegration of the high-velocity liquid jet issuing from nozzles depends on the fluid discharge velocity, its physical properties, resistance of the medium into which the discharge takes place, the initial parameters of the liquid, and other factors. The main factors are the surface tension of the liquid and the effect of the surrounding medium [1].

The jet disintegration becomes more effective and much faster with increase of the initial temperature of the liquid being sprayed because of more intense spreading of the jet, more intense vaporization from the jet surface, and also because of reduction of the surface tension forces and change of the nature of the jet pulsation and of the velocity potential. Moreover, change of the temperature of the sprayed

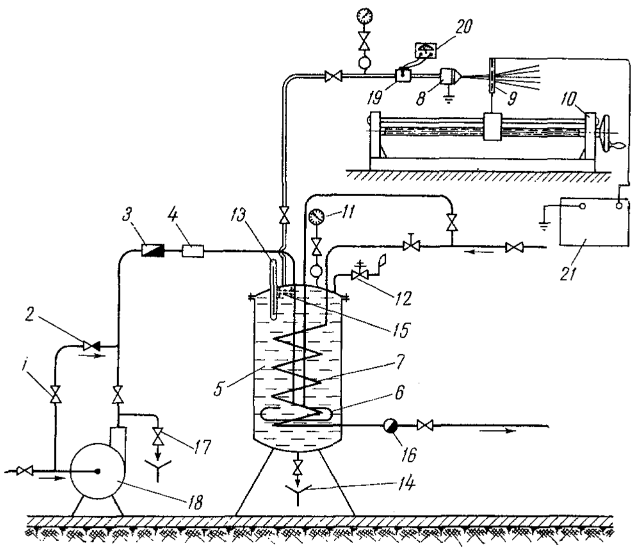

Fig. 1

Kaunas. Translated from Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, Vol. 11, No. 3, pp. 147-149, May-June, 1970. Original article submitted October 22, 1969.

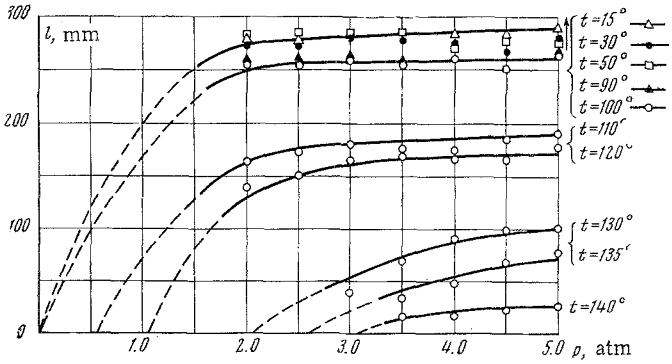

Fig. 2

liquid is associated with change of its kinematic viscosity which, in turn, determines the degree of turbulence of the jet and also the nature and rate of its disintegration. In this connection there is also a change of the time of initiation of jet disintegration, measured from the moment of discharge, which is defined by the ratio

$$T = l / W \tag{1}$$

where l is the length of the continuous part of the jet; W is the average liquid velocity (approximately equal to the velocity at the moment of discharge).

Most investigators [1-4] have studied the disintegration of a liquid jet for various spraying techniques, basically as a function of the initial pressure of the liquid being sprayed. However the question of disintegration of a sprayed liquid as a function of the initial liquid temperature has received very little study.

The experimental studies of water jet disintegration were made using the well-known technique of [2, 3] on the experimental setup shown in Fig. 1. The experimental setup operates as follows. Water flows from the mains through the valve 1, check valve 2, water meter 3 for monitoring the amount of water, and the magnetic filter 4 into the preheater 5, in which it is heated by steam by means of the open and closed coils 6 and 7. Water from the preheater with definite parameters (p, t) is sprayed by the nozzle 8. The length of the sprayed jet is determined by the familiar electrocontact method with the aid of the grid 9, which can be moved fore and off by the special screw device 10. The centrifugal pump 18 is connected in parallel with the main water line to maintain the required pressure in the preheater. With the pump operating the pressure in the preheater can be regulated by the valve 17, which bypasses part of the water from the pump outlet back into the drain system. In the case in which the nozzle forms a continuous water jet over the grid, oscillations with asymmetric amplitudes are seen on the oscillograph screen. As the metallic grid 9 is moved away from the nozzle a moment is reached when the continuous jet does not reach the grid. On the screen there appear new peaks and the symmetry of the oscillation is disrupted. The other elements of the setup include: 11 = manometer, 12 = safety valve; 13 = thermometer; 14 = return to drain; 15 = mesh filter; 16 = condensate vessel; 19 = thermocouple well; 20 = millivoltmeter; 21 = electrocontact instrument complex.

In order to see the effect of temperature on the disintegration of the liquid jet more clearly, we used a straight-through nozzle of the P-3 type with different diameters of the exit port and without the helical (internal) part, since otherwise the very short undisintegrated jet segment makes it very difficult to evaluate the influence of temperature on jet disintegration.

The experiments showed that not only the initial parameters (p, t) of the water being sprayed, but also the diameter of the exit port and the parameters of the surrounding air have considerable effect on the length of the undisintegrated liquid jet.

Figure 2 shows the continuous jet segment length l (mm) as a function of the pressure p (atm gage) of the water being sprayed $l = f(p)$ for different water temperatures for the nozzle diameter d = 1.7 mm.

We see from the figure that when spraying water with temperatures from 15 to 100°C the length of the continuous part of the jet is comparatively large and with increase of the initial water pressure this

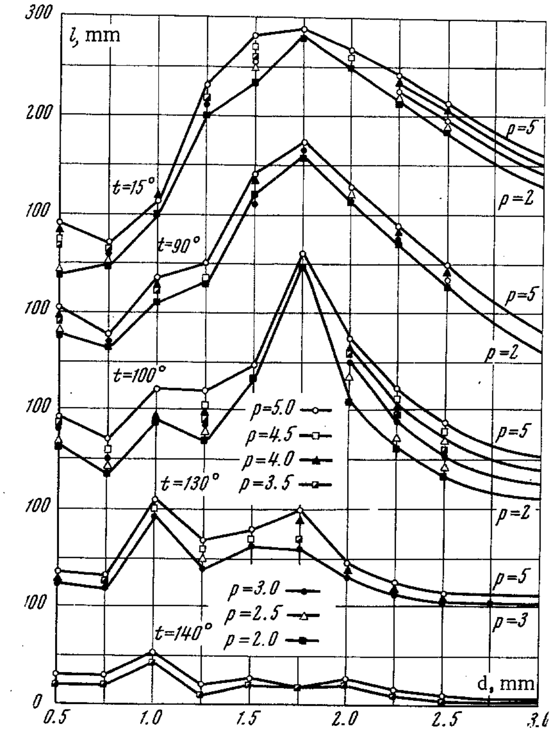

Fig. 3

length increases only slightly, and increase of the temperature from 15 to 100°C also has very little effect in reducing the length of the continuous part of the jet.

With increase of the sprayed water temperature above 100°C – in the range from 100 to 120°C – we note more marked reduction of the length of the continuous part of the jet. However, as a result of slight superheating of the water (moreover, there is some decrease of the temperature and pressure in the nozzle itself) we see from Fig. 2 that the magnitude of the length of the continuous part of the jet has a transitional nature. A marked reduction of the length of the continuous part of the jet is noted with approach of the water temperature to the boiling point (although the other conditions remain unchanged). However, increase of the pressure of the sprayed water in these cases has more effect (for t_w = 130-140°C) in increasing the length of the continuous part of the jet than when spraying water with temperatures up to 120°C. The experiments conducted showed that the nozzle diameter does not have the same effect on the length of the continuous part of the jet for different temperatures of the sprayed water.

Figure 3 shows the effect of nozzle diameter on the length of the continuous part of the jet for different pressures (2-5 atm gage) for different temperatures of the sprayed water. We see from Fig. 3 that the previous statement is confirmed, that up to a temperature of 90-100°C the jet length has its maximal value for a nozzle exit port diameter d = 1.5-1.8 mm and for water temperature above 120°C, i.e., when spraying superheated water with large superheat, the overall jet length decreases sharply and has its maximal value when the nozzle diameter is reduced, i.e., for d = 0.8-1.2 mm.

As the superheated water temperature approaches the boiling point the maximal length of the continuous part of the jet shifts still further toward the coordinate origin and its maximal value decreases still further.

Summarizing the test results, we note that disintegration of the sprayed water jet depends to a great degree on its initial temperature. The tests also established that in the low pressure range (2-5 atm gage) the length of the continuous part of the jet increases slightly with increase of the pressure, however the minimal length is reached only for a definite nozzle diameter and when spraying superheated water whose temperature is close to the boiling point.

We see from Fig. 3 that the pressure of the water being sprayed in the range from 2 to 5 atm gage has no significant effect, therefore this factor can be ignored in calculations in particular cases.

Using the relations found for the different parameters of the liquid being sprayed and knowing the experimental conditions, we can find the connection between the nozzle diameter and the length of the continuous part of the jet.

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