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TRANSLATION

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GAS GENERATOR

By

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BASES OF BURNER THEORY FOR LIQUID FUEL WITH GAS GENERATOR

N. S. Lamokin

In this report are given the basic conditions of the theory of liquid fuel forcing burner with gas generator. According to the principle of the theory of decomposition of a liquid stream is arranged the cavitation process, formed at the output from the forcing channel by the gas flow of the generator, having a periodic structure, which offers the possibility of reducing the pressure of the liquid at input.

In this report are also given experimental data, confirming the good quality of liquid dispersion and excellent convergence of the premises, taken as a basis for the calculation of the burner, principally distinguishing same from all other existing ones.

The existing theories of liquid dispersion explained the decomposition of the stream after the spray came out from the nozzle without consideration of the intrachannel decomposition.

Analysis of phenomena shows, that the cause of dispersion of the liquid at definite conditions may appear to be the cavitation process, causing decomposition of the stream still in the sprayer channel.

The known theories of liquid stream decomposition confirm experimentally only in a limited range of pressure and velocity drops. Yes, the theory of stream decomposition, taking into consideration small fluctuations of its surface [1], can be applied only to the rate of outflow of 10-12 m/sec.

In many reports, discussing the outflow of liquid through channels and, especially, through the sprayer channels[2], is shown that a destruction in the solid stream of the liquid can take place in its narrow section according to Bernoulli

$$P_2 = P_0 + \frac{\gamma V_0^2}{2q} - \frac{\gamma V_2^2}{2q} \quad (1)$$

In case, when the pressure of the liquid in front of the sprayer $P_0 = 50 \text{ kg/cm}^2$ and the rate in the channel $V_2 = 100 \text{ m/sec.}$ and $V_0 = 0$, we will obtain $P_2 \approx 0$, that is in the channel of the sprayer should be expected stream cavitation over the entire section. At such a decomposition of the liquid many investigators recorded high frequency oscillations.

After we have taken the frequency characteristic of a sprayer of VK-1A engine [3] it became apparent, that the decomposition of the stream into droplets is due to cavitation, having formed in the sprayer channel. Averting cavitation phenomena in the sprayer channel (changing the form of input, pressure, rate of output from the sprayer, by affecting the stream with sonic and ultrasonic oscillations, it is possible to reduce P_0 .

It is known, that the air, leaving the nozzle under excess pressure of 0.9 gage atmosphere, has a rate of outflow, exceeding the rate of sound propagation [4]. This stream acquires a periodic structure, as is shown by curve K (Fig. 1).

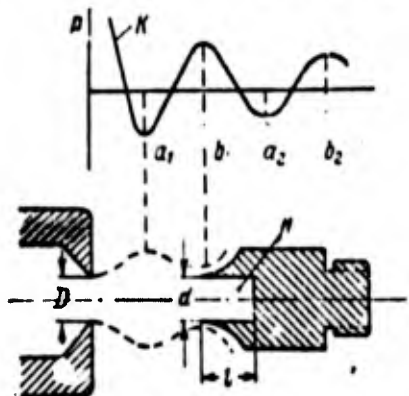


Fig. 1. Periodic structure of stream during an outflow of gas from nozzle D.

This phenomenon is explained by the fact, that the rate of gas outflow from the nozzle of the generator exceeds the rate of sound propagation in that gas[5].

On sections a_1b_1 ; a_2b_2 and others, where the pressure rises, the stream is unstable. Placing in this stream a generator (resonator) H, we obtain a radiation of sonic or ultrasonic waves depending upon the basic data, accepted during the calculation of the generator.

On this basis was created a device for the dispersion of liquid. At present time were introduced several variants of spraying devices[6].

Here are explained the principles of the burner theory with gas generator.

When the sound passes into the liquid instantaneous pressure equals

$$P_0 + P_u \sin \omega t, \quad (2)$$

where P_0 - static pressure; P_u - sonic pressure.

Maximum negative pressure $P_0 - P_u$ - the critical pressure of cavitation origination.

Knowing the area of this section of the liquid shrouds, which are under the effect of variable generator pressure, from equation (2) can be found the force P_m affecting the liquid.

The work of this force

$$A = \delta P_m, \quad (3)$$

where δ - thickness of liquid shroud, flowing out through the gap in the sprayer.

In this way, we have found the first dependence to find the working condition of a gas generator, assuring the decomposition of the liquid at the output of the layer from the sprayer.

Furthermore, it is possible to accept the constancy condition of the surface energy of the system, which will give the possibility of calculating the work, lost for the formation of droplets

And so, if the surface increases from S_2 to S_1 , then the corresponding work would be

$$A_1 = \alpha (S_1 - S_2). \quad (3a)$$

The volume of the droplet of radius r_0

$$V_0 = \frac{4}{3} \pi r_0^3, \quad (3b)$$

the surface of this droplet

$$S_0 = 4 \pi r_0^2. \quad (3c)$$

In volume V are contained n_0 droplets

$$n_0 = V \frac{3}{4 \pi r_0^3}. \quad (3d)$$

Disregarding the initial surface of liquid S_2 , we will obtain

$$W_1 = \alpha n_0 S_0 = \frac{3 \alpha}{r_0} V. \quad (4)$$

The job of granulating the water of a volume of $V = 250 \text{ cm}^3/\text{sec}$ into droplets of radius $r_0 = 70 \text{ micro} = 0.07 \text{ cm}$

$$W_1 = 70 \cdot \frac{3}{0.007} 250 = 5.3 \cdot 10^5 \frac{\text{erg}}{\text{sec}} \approx 0.05 \frac{\text{вт.сек.}}{\text{вт.сек.}} \quad (4a)$$

We will make a comparison of sonic pressure for given generator powers.

It is known, that sonic pressure at a distance r from the point source is connected with its power by the ratio

$$W = \frac{P^2}{2\rho C} 4\pi r^2, \quad (5)$$

where P - sonic pressure; ρ - density of the medium; C - speed of sound in a medium.

From equation (5) follows, that in air ($\rho = 1.29 \text{ g/cm}^3$; $r = 0.07 \text{ cm}$) to power of 2000 w corresponds a pressure

$$P_1 = \sqrt{\frac{2\rho C W}{4\pi r^2}} \approx 1 \cdot 10^3 \frac{\text{dyn}}{\text{cm}^2} \approx 1 \text{ atm}, \quad (5a)$$

and to power of 0.05 w the pressure

$$P_2 = 5 \cdot 10^2 \frac{\text{dyn}}{\text{cm}^2} = 5 \cdot 10^{-2} \text{ atm}, \quad (5b)$$

Pressures P_1 and $P_2 \gg \rho$ sickness threshold $\approx 10^3 \text{ dyn/cm}^2 = 10^{-3}$ gage atmospheres.

For a generator with $l = d$ at a frequency $\nu = 20 \text{ dgc}$; $d = 0.3 \text{ cm}$ we determine the acoustic power, which equals first approximation

$$W = 3d^2 \int_0^{\pi} P^2 \sin^2 \theta d\theta \quad (6)$$

Then for $W_1 = 2000 \text{ w}$; $P = \frac{W}{d^2} \approx 0.9$; $P_1 = 10^3$ gage atmospheres.

For $W_2 = 5 \cdot 10^{-2} \text{ w}$; $P_2 \approx 0.9$ gage atm.

On the basis of these calculated conditions, was prepared a sprayer.

In Fig. 2 is shown a structural variant of a sprayer with internal, with respect to fuel stream, disposition of ultrasonic generator, which created the condition, expressed by equation(2).

In the body 1 of the sprayer is situated bushing 2, forming with it an annular hollow 3, where to the liquid goes, and creating ultrasonic oscillations generator, made in form of a tube with hollow-resonator 4 and wedge slot 5. The head 6 of the generator is pressed down to bushing 2 by a clamping nut 7, through intermediate bushing 8.

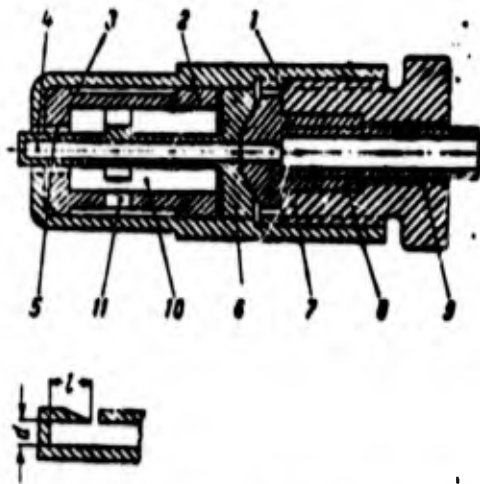


Fig. 2. Sprayer with internal, with respect of fuel stream, situated gnerator.

The compressed air goes into resonator 4 through tube 9, and the liquid fuel goes into the internal hollow 10 of bushing 2 through a window 11[6].

Into the sprayer generator was fed nitrogen gas (in other experiments air) under a pressure of from 1 to 4 gage atm (successively through one atm). The quality of dispersion was checked at low

liquid pressures at the input into the sprayer under the effect of these oscillations to the shroud of liquid. In Fig. 3 are given distribution curves for two of the obtained sprayer working conditions.

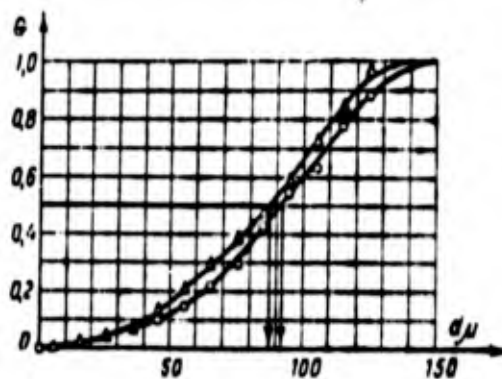


Fig. 3. Droplet distribution curves in dependence upon their diameter $G\% = f(d)$.

As is evident from the curves, the average diameter of droplets equals 92 microns at a pressure of the liquid $P = 4\text{kg/cm}^2$ and air pressure in generator of 1 gage atm. In the second case, at the very same liquid pressure and air pressures in the generator equalling 4 gage atmospheres, the average diameter of droplets equalled 87 microns. In the first and cond. cases the delivery of air has not exceeded 5% of maximum delivery of liquid.

Comparing these values with the calculated value, it should be considered, that the obtained good convergence of diameter values pertained to all droplets. If it is considered, that at

present time one of the essential deficiencies in the work of centrifugal sprayers at low pressures appears to be the greater diameter of the droplets, reaching 200 microns and over (or instead of droplets a greater jet stream begins), and in pneumatic sprayers there is a greater delivery of air (ratio of air and liquid is approximately 1:1) then it will become apparent the advantage of the sprayer with gas generator.

In this way, experimental investigations of the sprayer with gas generator confirmed the explained bases of the theory.

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