Designing of the Cavities Device Circuit for Installation in Canal of Fan Sprayer

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Keywords: Cavitation Device, Spray Optimization, Droplet Dispersion.

Abstract: In article is described the structure, operation and advantages of the spreader (caviator) used in the fight against pests and diseases in agricultural crops, viticulture and horticulture, as well as its advantages over other spreaders. Also, installing the caviator device on the nozzle of fan sprayers (passing the symmetry of the axis equal to "k-k" passing through the center of the spray nozzle and selecting point "a" from it, passing horizontal lines from point "a" to create points " c " and " b ", A scheme was designed to find the point d that defines the triple part of the conical expander by passing a line 45^0 below the point " b ", and to determine the point "e" where the axis symmetry of the capillary channel passed at a distance of l_0 from the point "d". The optimal design parameters of the caviator (diameter of the base of the conical expander that expands the liquid droplet flow, internal diameter of the injection chamber) are defined in the article. In order to deliver liquid droplets to a long distance, the method of installing the cavity nozzle at an optimal distance from the fan nozzle, the distribution of the free air flow from the spray fan in the atmospheric environment and the methods of selecting the operating modes of the spraying process (the speed of the air flow containing liquid droplets), the performance of the fan sprayer were determined.

1 INTRODUCTION

The yield and weight of the product in agricultural crops depend on the type of seed planted, the strength of the land, the period of planting and vegetation, as well as the contamination of the fields with disease-spreading microorganisms, the extent of contamination with diseased plant residues, the types and levels of disease spreaders and pathogens. Disease infections and disease-spreading pests in most cases can multiply in the roots of weeds in the initial phase of development and then spread to cultivated plants (Matchanov, 2016; Akhmetov & Mirzaev, 2018; Farmonov, 2020; Matmurodov, 2020; Eshpulatov et al., 2021; Matchanov et al., 2021; Djiyanov, 2022; Djiyanov et al., 2024).

To fulfill these tasks, it is important for farms today to increase productivity using intensive technologies in the field of agriculture, to protect the crop from pests, diseases and weeds.

Increasing their volume and quality due to the reduction of losses caused by most pests, diseases and weeds to agricultural products, reducing the negative impact of existing spraying technologies on the environment and people, solving the problems of its prevention is reflected in the integrated protection of plants.

The size of the spray droplets determines the effective effect of the chemical or biopreparation and the economic efficiency of the treatment. As the droplet size decreases, i.e. as the level of spray quality increases, the working fluid consumption decreases.

According to experts, the technical efficiency of using boom sprayers for pre-harvest defoliation or desiccation of cotton in the small-volume spraying method is high because the spraying process is carried out close to the cotton stalks. In this case, the

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Irisov, K., Djiyanov, M., Bekmurodov, I. and Abdiyev, N.
Designing of the Cavities Device Circuit for Installation in Canal of Fan Sprayer.
DOI: 10.5220/0014224000004738

In *Proceedings of the 4th International Conference on Research of Agricultural and Food Technologies (I-CRAFT 2024)*, pages 148-152
ISBN: 978-989-758-773-3; ISSN: 3051-7710

preparation is carried out due to the kinetic energy of the treated liquid under the influence of gravitational force and partial air flow (Derksen, 1994; Podgornyj, 2021; Usenov, 2021; Khaliknazarov et al., 2021; Khaliknazarov & Ibrokhimov, 2024).

Many authors have proven in their studies that the use of fan sprayers in a small amount mode is effective in the treatment of cotton fibers (Jobnson & Swetnam, 2000).

Different types of sprinklers are being produced in the world (Sudit, 1973) and complex scientific and practical research works are being conducted to create their new projects(Sudit, 1973; Jobnson & Swetnam, 2000; Alimova et al., 2022; Irisov & Bekmurodov, 2023; Khudayorov et al., 2023a; Khudayorov et al., 2023b; Irisov & Khamidov, 2023).

It is possible to chemically treat the underside of the plant leaves with the help of the air stream created on the side of the spray fan. The advantages of oscillating fan sprayers in the horizontal plane are the ability to quickly maneuver on turning lanes, the large coverage width, the ability to process plants from both sides along with their entire height.

Based on the results of the analysis, a working hypothesis was adopted that the formation of highly dispersed droplets can be achieved by the influence of the kinetic energy of the local and main air currents generated by the spray fan on the thin liquid film that is ejected from the nozzle slit (Irisov & Bekmurodov, 2023; Irisov & Khamidov, 2023).

2 MATERIALS AND METHODS

We use the M2:1 scale to design a schematic for installing a cavitation device (Irisov & Bekmurodov, 2023; Irisov and Khamidov, 2023; Saidova et al., 2024) on a fan spray nozzle, which creates a thin film of liquid that is ejected from the nozzle's annular slit to produce highly dispersed droplets (Figure 1).

The design stage consists of:

We transfer the symmetry of the axis equal to "k-k" passing through the center of the spray nozzle and select the point "a" from it.

We create points "c" and "b" by passing horizontal lines from point "a". Let's define the distance between these points. From the constructive side, "ac" and "ab" are equal to rk. Therefore, we can find the diameter of the base of the conical expander that expands the liquid droplet flow from the following expression ($a = 10\ mm; \beta = 45^0$):

$$d_k = 2r_k = 2\frac{a}{tg\alpha} = \frac{10}{\sqrt{\frac{2}{2}}} = 15\ mm$$

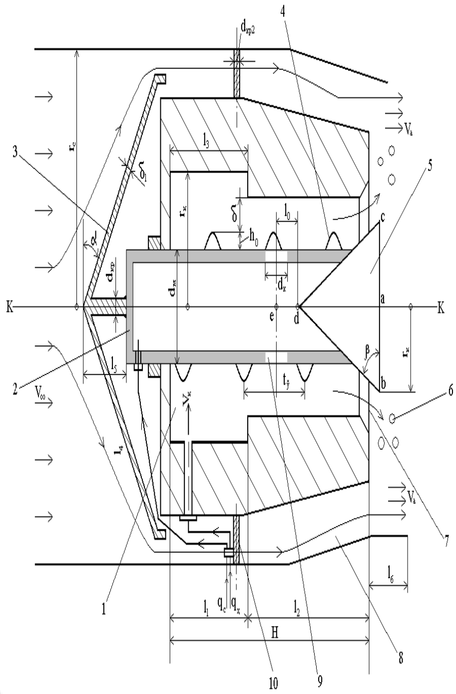

Figure 1: Designing the scheme of placement of the Caviator device on the fan spray nozzle: 1 – feeding chamber; 2 – central tube; 3.5 – current expanders; 4 – spiral deflector-turbulizer; 6 – small drops; 7.8 – nozzle; 9 – capillary channel; 10 – bracket.

We pass the beam 45^0 below the point "b" and find the point d, which defines the third part of the conical expander.

We determine the point "e", which is 6 mm from the point "d", where the axial symmetry of the capillary channel passes, in which from the structural side

We accept equal to

$d_k = 3...4$ мм ; $h_o = 2$ мм ; $\delta = 1{,}5...2{,}0$ мм ;

$t_y = 1{,}5...2$ мм ; $d_k = 40$ мм ; $d_{kp2} = 4$ мм ; $d_м = 14$ мм

We determine the inner diameter of the feeding chamber in the following proportions:

or

$$d_к = \frac{d_м}{2} + \Delta,$$

$$d_к = \frac{14}{2} + (3...6) = \frac{14}{2} + 4 = 10{,}2 \approx 11\ мм.$$

As the fluid consumption decreases, it is recommended to take the value of *Δ* as low as possible. Otherwise, the process of crushing the drops coming out of the caviar nozzle will be much more difficult.

The number of spiral windings in the deflector-turbulizer should not be less than 2..3 on the upper and lower sides of the capillary channel 9. Too few or too many packages can adversely affect the stability of the worker being transferred.

A conical flow expander 3 is poured on the windward side of the cavity. It allows the flow of air transmitted by the fan to surround the caviar without great resistance, and the small liquid drops ejected from the caviar nozzle 7 can mix deeper with the air flowing around the spray nozzle and deliver them to a longer distance, thus increasing the technical efficiency of the working fluid used.

The second way to deliver liquid droplets to a long distance is to install the cavity nozzle 7 at an optimal distance of 16 from the fan nozzle 8. Because the initial velocity vo of the air to the triangular core of the turbulent air flow from the nozzle 8 (dashed in Fig. 2) is constant and the length of the distance is equal to $e=0,335d/\eta$ - (where d is the diameter of the core of the fan nozzle; *d* - turbulence coefficient (fountains for η=0.07...14).

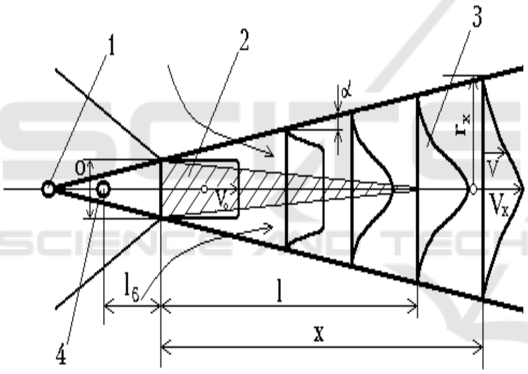

Figure 2: Distribution scheme of the free air flow coming out of the spray fan in the atmosphere: 1 – flow pole; 2 – current core; 3 – transition section; 4 – the point where the caviar nozzle is installed; d - nozzle diameter; v_o – the initial speed of the air leaving the nozzle; a – expansion angle; r_x – the radius of the cross-section of the fountain at the distance *x* from the nozzle; η - turbulence coefficient.

3 RESULTS AND DISCUSSION

Velocity of air flow with liquid droplets in the axis of symmetry of the section at distance "*x*" from the nozzle:

$$v_x = 0{,}48 v_o /(ax/d + 0{,}145), \text{ m/s} \quad (1)$$

Fan sprayer performance:

$$Q = sv_{ўрт}, \; m^3/s; \quad (2)$$

$$v_{ўрт} = (0{,}75...1{,}0)\, v_o, \; m/s, \quad (3)$$

where, s – is the cross-sectional area of the fan nozzle, m^2;

v_{aver} – the average speed of the air coming out of the nozzle, *m/s*.

Moving away from the axis, the speed v_o decreases and becomes zero at its extreme point. The air velocity vx at any cross-section of the main part located in the core of the flow is zero at the flow limit (distance R_x), decreasing as it moves away from the fan nozzle.

Fluid flow rate that should flow out of the caviator device every minute:

$$q_c = \frac{Q_c B v * n}{600}, \; l/min \quad (4)$$

where B – is the coverage width of the aggregate during processing, m; v – unit speed, km/h; n – the number of cavities installed in the nozzle, pcs.

Working fluid consumption qc can also be determined using a nomogram (Figure 3).

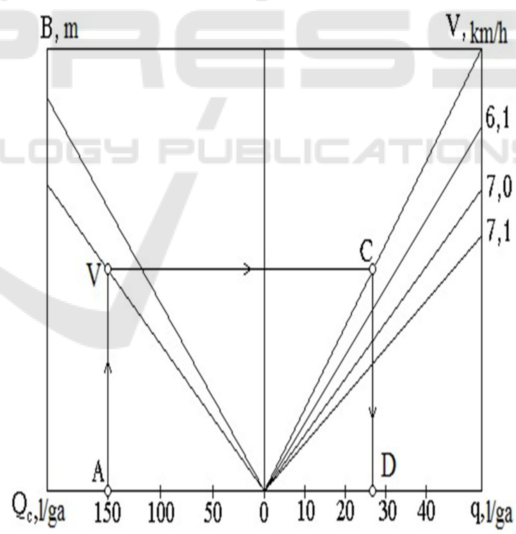

Figure 3: Nomogram for determining the required amount of working fluid.

For it, the fluid consumption Q_c given from the nomogram is selected and the quantity q located on the abscissa axis along the arrow A→V→S→D is found. If q<50 l/ha, the eye of the side capillary channels in the central tube is adjusted closer to the nozzle 7 and the liquid consumption is reduced, if q>50 l/ha, on the contrary, the eye of the side capillary channels is pushed into the cavity of the condensing chamber 1 and the liquid consumption is increased. It is also possible to use the central tube, which corresponds to the cavity of the side capillary channel.

Both high-dispersed and polydispersed drops are formed from the recommended carrier systems and have universal properties. And traditional zasitkikh systems do not have such an opportunity.

At the end of the design, the main contour lines of the cavity device and the fan nozzle are drawn in dark color.

4 CONCLUSIONS

The use of the correction system of Caviator devices allows obtaining both highly dispersed and polydispersed droplets in a given spray unit itself.

The treatment system of the Caviator devices can also be used as boom sprayers.

The above-mentioned expressions and design allow to choose the most optimal constructions of caviators, to justify their main parameters and operating modes.

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