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Increasing of the Intensity Processes of the Formation and Deposition of Aerosol Particles with Application of Electric Charger

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Abstract: It was taken into consideration the possibility of application of sprayer with electric charger with specific parameters that allows increasing the intensity of processes the formation and deposition of aerosol particles on the object of processing.

Key words: Aerosol, spraying, dispersibility, induction charge, switching circuit, synchronous generator

INTRODUCTION

Aerosols play an important role in nature and in human life. Last years in many industries of national economy, including in a technique, agriculture, medicine and veterinary science they find a wideuse (Blazhenov *et al*., 1983). Creation and improvement of the system spraying fluid resulting aerosol at different purposes of processing were involved by Dunskiy V.F., Nikitin N.V., Polyakov L.A., Ginsburg R.M., Sokhta A.A. and etc. In veterinary medicine, these issues are devoted the works of Dyklop V., Yarnykh V.S., Zakomyrdin A.A., Ivashkov I.S., etc.

On the basis of the study researchers considered above working hypothesis has been put forward about the possibility of the formation of aerosol particles in the treatment zone through the use of nebulizer electric charger with certain parameters which allow to stabilize the formation of monodisperse particles fight disease and protect the plants. Working hypothesis formulated objectives of the study which examined ways of formation of monodisperse particles in the fluid rotating disk fragmentation as well as analyzed regularities-minute motion of a fluid in rotary atomizers with circular and rectangular cross section pipe which led to the conclusion that the use of spray pipes directed forward are efficient than rear-facing.

DISCUSSION

When dispersing (splitting) of the working fluid one of the main difficulties is the need to produce finely divided spray with minimal (Dunskiy and Nikitin, 1981; Nikiforov, 1973). There are two methods of dispersing liquids which currently widely adopted. The first is the use of aerodynamic forces of the field, the second is the use of electrostatic effects. However, due to incomplete accounting features dynamic impact liquid droplets with the environment the possibility of the second method of dispersion has not been implemented in full. It is known that dispersing of the spray liquid related to their ability to “explode”, i.e., cavitation. For the stability of the drops has been accepted the following term:

$$\frac{\rho V^2}{2} \text{ and } \frac{4\sigma}{d_k} \text{ or R and P}$$

Where:

- ρ = Density of streamlined air (kg/m^3)
- V = The relative velocity of the droplets in the air (m/sec)
- б = Coefficient of surface tension of the liquid (J/m^2)
- $d_{Droplet}$ = Diameter of droplets (μm)

Droplet shape is considered as: stable at R<P; unstable at R = P; most unstable at R = P; R>P. Since, the release of the liquid ring in the form of the boundary sub-layer from the outfall of the nozzle pipe it goes and actively destroyed by streamlined flow.

In the scheme (Fig. 1) the signs “+” and “-” designated areas of high and low pressure of the drop in the interaction with the air flow. Frontal forces flattened the droplet, others pull it from the sides by “stern”, a droplet of a spherical shape becomes disk-shaped.

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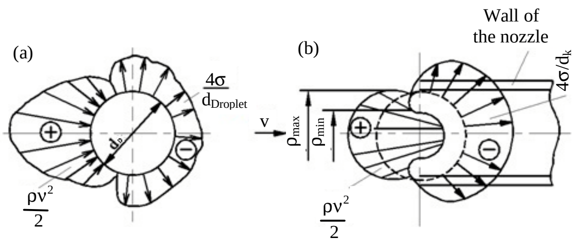

Fig. 1: The pressure distribution on the surface of the deformable droplet: a) droplet in the flow of streamlined environment; b) droplet on the outfall of the nozzle pipe

Electric charging liquid, being a powerful contributing factor in the use of our proposed method of grinding fluid may result in a thin liquid ring size $\delta = \rho_{max}-\rho_{min}$ and as a consequence, increase the intensity of the formation of fine particles as well as the process of their deposition on the treated object.

Since, the release of the annular liquid in a thin boundary sub-layer from the outfall of the nozzle pipe it goes and actively destroyed by streamlined air flow as has the windage. The microprotrusions rough surface of the pipe nozzle and the vibrational motion streamlined jet air stream around the accelerating tube leads to intense cavitational thin annular dispersing fluid into aerosol droplets. Using the electric charger is an additional factor in the precipitation of aerosol particles on the processing object. Currently, however, these physical processes occurring in the interaction of droplets with a streamlined flow of air and the electric field strength almost not used to improve the quality of dispersion as well as the deposition of the spray liquid.

It is this feature of the dynamic effects of the droplets with the streamlined flow of air was taken into account when we develop a new sprayer equipped by electric charger. Sprayer equipped by electric charger (Utemuratov *et al*., 1990) shown in Fig. 2. The sprayer operates as follows.

The working fluid through the conduit 1 is continuously supplied into the cavity 5 and further through with rotating blades of activator 23 it is injected into the cavity 24 of the separator drum 6. By centrifugal force and pressure activator blade 23 the working fluid passes by annular gap of disk-turbulator 8 into polygonal pores of the filter element 9. The largest suspension which not passed by annular gap of disk-turbulator 8 is thrown aside of the outlet valve 11 a shut-off mechanism 7 at spray which rotating with an angular velocity (ω).

The smallest size of suspension (particles) is further treated before filtering element 9, the remaining particulate matter are sorbed in the pores of the filter element 9. The turbulence of fluid flow in zone of the annular gap separator drum 6 increases the intensity of the cleaning liquid from the smallest suspensions.

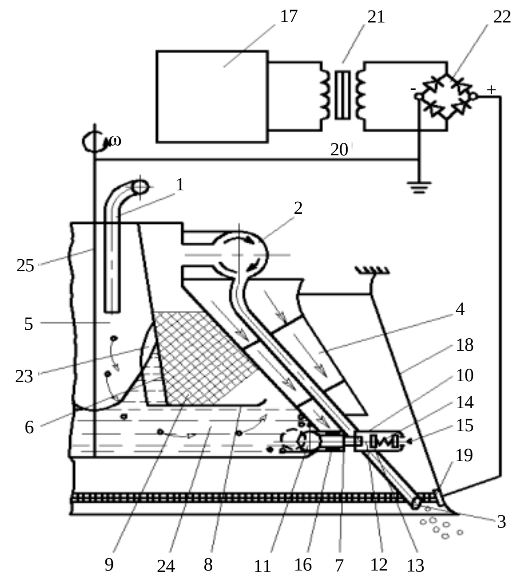

Fig. 2: Sprayer of inertial action (sectional side): 1: the working fluid nozzle; 2: torus-shaped disk; 3: spray tips; 4: ventilating element; 5: cone-shaped cavity; 6: separator drum; 7: the shut-off mechanism; 8: ring disk turbulator; 9: the filter element; 10: tubular conduit; 11-outlet valve of the centrifugal action; 12: rod; 13: support; 14: thoriated spring; 15: adjusting screw; 16: side cut-out window for the withdrawal of washable sediments; 17: three-phase asynchronous generator; 18: conical cover; 19: induction ring; 20: electrode; 21: transformer; 22: diode rectifier; 23: activator; 24: feeder pipe; 25: the drive shaft

Cleaned working fluid via the deferent pipe of the separator drum 6 enters the cavity toroidal disc 2 and then it through pipe of spray tips 3 is transported down to their nozzles where it occurs the formation of a liquid thread. With the inclusion of the sprayer, synchronous generator 17 is driven to rotate.

Generated a voltage is applied through the control panel and switched circuit to the electric motor drive shaft 25 of sprayer.

Formed liquid thread falls within the zone of inductive charging and as a result of forced and additional action of aerodynamic flow occurs an intensive crushing of these threads of liquid on aerosol particles. Aerosol particles become electrically charged by carrying out a certain amount of unipolar ions from induction charge area.

It prevents backflow of the electrically charged aerosol stream toward the inducing electrode 19 the electric charger since the power of the aerodynamic flow F_{air} (Fig. 3) which is generated by venting element 4, greater than strength of the electric field F_{elec}.

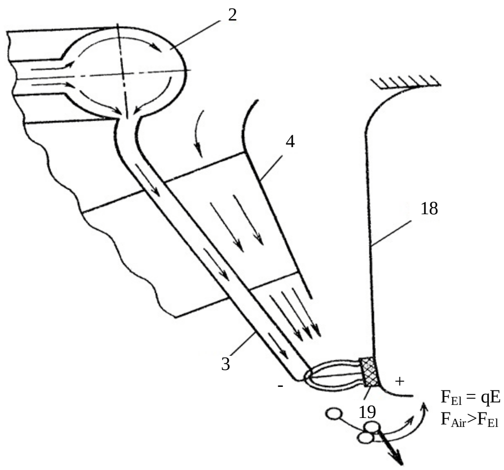

Fig 3: Scheme of forces of aerodynamic flow on electro charged aerosol

Depending on the work mode of sprayer it occurs automatic alternation of the cleaning processes of the cavities of drum separator 6 and aerosol treatment of plant. The design of the shut-off mechanism 7 is simple and convenient to operate.

Thus, in the proposed atomizer may increase the automation of cleaning fluid from the smallest size mechanical suspensions and the cavities of the separator drum 6 as well from large mechanical deposits synchronously depending on changes in the speed of movement of the apparatus as well as to increase the intensity of the formation of aerosol particles from the moment of the descent of the liquid thread from the edge of the nozzle spray tips 3. Herewith the electrical charge of the liquid can contribute enhance the efficiency of deposition process of the obtained aerosol particles on the processed object.

There were conducted laboratory studies to confirm the effectiveness of the chosen direction and assessment of above developed prerequisites. Laboratory experiments to determine the quality indicators of the operation of liquid atomizer were performed according to Industry Standard (IS) 70.6.1-82.

To determine the optimal parameters of the formation of aerosol droplets and sedimentation at object processing it was applied the theory of planning multifactor experiment. Objective of optimization was the obtaining monodisperse aerosol droplets and their sedimentation on the surface of the processed objects within optimal parameters and operating modes of sprayer.

To find the optimal values of these parameters, it was used the method of mathematical planning of the experiment in which for optimality criterion were taken diameter $d_{Droplet}$ (μm) of formed aerosol droplets and the density N (pcs/Sm^2) of the deposited aerosol droplets on a specific area.

To describe the optimal domain with three replications it was implemented the scheme of the central composite rotatable planning which consisting of multifactor experiment, maximal and three central points.

It was hold 15 experiments. The number of maximum points ±X = 2. The number of variables k = 3. The significance of the regression coefficients was tested by Student's test, the dispersion was evaluated according to the known formulas. These data allow to describe the process model in the form of regression equation:

$$Y_0 = B_0 + \sum_{i=1}^{3} b_i X_i + \sum_{i=1}^{3} b_{ii} X_{ii}^{z} + \sum_{i=j}^{3} b_{ij} X_{ij}$$

After describing the regression equations it was defined their adequacy by criteria of Fisher. To study the response surface ,it was adjusted in the canonical form of the equation to determine the qualitative and quantitative indicators by forming monodispersed aerosolic droplets, using methods of Mathematics and Computer Science. Using the method of search for optimal sphere for equations of second level it was set the type of response surface and the ways of finding the extremum in the field of experiment.

By the method of two-dimensional sections, it was studied the response surface and was determined the optimal values of design and technological parameters of the sprayer.

The coefficients of the regression equation at rotatable planning determined by the known formulas. While the number of experiments N = 15, number of variables E = 3, central points = 3, peripheral points = 15.

Based on analysis of regularity of obtained results and implementation of the Benkin's of matrix-optimal plan it was obtained the regression equations adequatelydescribing the process of formation and deposition the monodispersed aerosolic particles: by magnitude of formed aerosols:

$$Y = 96.9 + 19.4X_1 - 22.8X_2 + 21.2X_3 + 7.6X_1^2 + 30.6X_2^2 - 23.6X_3^2 + 20.8X_1X_2 + 1.18X_1X_3 + 3.6X_2X_3 \quad (1)$$

On the density of deposited droplets on:

$$Y = 127.2 - 21.5X_1 + 44.06X_2 - 3.6X_3 + 56.05X_1^2 + 15.83X_2^2 - 28.43X_3^2 - 9.05X_1X_2 - 6.5X_1X_3 + 0.275X_2X_3 \quad (2)$$

CONCLUSION

Review of analytical relationships which was established in theoretical analysis of studied process of the formation and deposition of the aerosol particles on the object of processing showed if at the adjusted modes of sprayer and theoretical diameter $d_{Droplet}$ of formed aerosol droplets are 105 μm at a density N = 100-110 (pcs/Sm^2). In the experiments actual particle with diameter $d_{Droplet}$ = 87-105 μm at a density N = 95-120 (pcs/Sm^2) is 60-70% by weight of the atomized liquid, the difference between of the theoretical and experimental researches was 8-10% that confirming their compliance.

Besides, it was found deposition of aerosol particles >45-61% on the reverse side of experimental sheets due to the forces of the electromagnetic field generated by electric charger of the sprayer.

Thus, the use of the sprayer with an electric charger contributes the increasing of intensity and stabilization of the processes formations as well as deposition of aerosol particles on the treated object at the spraying. This ensures the rational use of a liquid preparation and ultimately reduces the degree of pollution of the environment in 2-3 times.

REFERENCES

Blazhenov, V.V., A.S. Dmitriev and V.V. Shishov, 1983. Substance monodispersion (on experiments of Savara and modern technology: Retrospective and perspective). Works Moscow Power Eng. Inst., 3: 3-14.

Dunskiy, V.F. and K.V. Nikitin, 1981. Monodisperserotating sprayer. Mechanization Electrif. Agric., 8: 11-14.

Nikiforov, A., 1973. Aerosols in Agriculture (No. FTD-HT-23-758-74). Foreign technology Div wright-patterson AFB OH. Moscow, Kolos.

Utemuratov, J.J., I.A. Ashirbekov, P.M. Musabekov, K. Umarkulov and S.N. Urazov, 1990. Patent Fund of Russian Federation. Certificate of authorship no. 1599110 USSR International Classification of Inventions (ICI) B05 B3/02,15/02 Sprayer. Newsl. Inventions, 38.