Development of short-range nozzle model for sprinkler machines

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Abstract. The issue of land reclamation modern technologies and technical means development is considered in the article, in particular, the improvement of the structures of sprinkle-forming devices in order to increase their use efficiency, which is a priority direction of scientific and applied research. A short-range deflector nozzle of one-piece design sector action was developed, it includes a replaceable jet nozzle, due to which the pressure at the outlet increases, thereby creating a greater vacuum and better dispersion of the water-air mixture. The jet, upon reaching the vertical splitter of the flow part, is divided into two equal flows, the upper one - passes by the vertical part of the spreader and directed to the deflector central part, and the lower one, in turn, is divided into two more flows by the vertical part of the spreader and directed to the deflector edges. This technical solution allows to improve manufacturability and reduce the product cost, as well as to increase the uniformity of the spray, the range of sprinkle drops flow and the sprinkle gripping area, which provides fine-drop sprinkling, the average diameter of the drops is 0.5 ... 0.7 mm, sprinkle drops from deflector nozzles flow range is 4 ... 6 m/s. With such sprinkle, the energy impact on the soil and agricultural plants decreases, the bulk density in the upper soil layer and the mass of the sprayed soil decrease, which leads to the increase in crop yields by 6.0-20.0%.

1. Introduction

The land reclamation modern technologies and technical means development, in particular, the sprinklers and sprinkle-forming devices designs improvement, in order to increase their use efficiency, is a priority area of scientific and applied research. Irrigation is an important factor in the intensification of agricultural production. Sprinkler irrigation is the most common method of mechanized irrigation. The sprinkler "Fregat" is the most widespread one in the reclamation complex in the South of Russia. Its share in the country and in the region, respectively, accounts for more than 42 and 76% of the total number of sprinklers. The advantages of the "Fregat" sprinkler are obvious: automatic irrigation around-the-clock work; high productivity, basic parts significant service life; simplicity of design and low cost in comparison with foreign sprinkler machines. The information and analytical materials analysis revealed the following disadvantages of irrigation by the "Fregat" sprinkler: unproductive losses, water for evaporation and drift, usually they are 10-15%, in hot daytime hours they can reach 20-30% or more; insufficient uniformity of irrigation in the wind, the
effective irrigation coefficient decreases to 0.5 ... 0.6. The most important direction in solving the above problems is the development of new irrigation techniques, taking into account the world trends in the land reclamation development, including the modernization of short-range deflector nozzles. Research objectives aimed at minimizing or eliminating deficiencies will provide significant cost-savings in water resources and will contribute to increasing crop yields. In this regard, improving the irrigation agrotechnical indicators of the "Fregat" sprinkler is an urgent task.

2. Materials and methods
On the research basis it was established that the sprinkler "Fregat" with near-surface sprinkling devices arranged according to the accelerated scheme provides the required water consumption both at standard and at low pressure. The height of the sprinkle cloud rise is reduced to 1.1 ... 1.7 m above the field surface, which ensures the decrease in water losses for evaporation and drift along the machine pipeline. Proportional dosing device with deflector nozzles provide fine-drop sprinkle, the average diameter of the drops at the beginning of the machine is 0.5 ... 0.7 mm, sprinkle drops flow range is within 4 ... 6 m/s. With such sprinkle, the energy impact on the soil and agricultural plants decreases, the bulk density in the upper soil layer and the mass of the sprayed soil decrease, which leads to the increase in crop yields by 6.0-20.0% [1-4].

Based on the sprinkler "Fregat" use effectiveness analysis and evaluation, there is data on the loss of water for evaporation during irrigation, taking into account the distribution of the drops size and rain intensity on the irrigated area, the height of the sprinkler installation, the individual sprinkle drop flow range and meteorological conditions. The dependence for calculating water losses for evaporation and drift during irrigation with various types of sprinklers is known, taking into account their design, technological parameters and meteorological conditions. We achieve the decrease in water losses for evaporation and drift by reducing the height of the sprinkle cloud and optimizing the spray parameters of the sprinklers [5-8].

3. Results and discussion
The cultivator for processing seed potatoes was designed (Fig. 1).

The short-range deflector nozzle of sector action contains a body including a lower part with an exterior thread, a longitudinal passage channel 1, radial holes 2, the inlet sharp edge 3 of a longitudinal passage channel 1, at the end of this edge the internal thread is made, into which a replaceable jet nozzle 4 is screwed; an upper part with a deflector 5 and a flat platform 6 connecting it to the body through the longitudinal passage channel 1, a vertical flow spreader 7.

Short-jet deflector nozzle works as follows. A water flow under the pressure of 0.05 ... 0.15 MPa, moving along the water-conducting belt of the sprinkler, enters the longitudinal passage channel 1. Since the sharp edge of the inlet 3 of the longitudinal passage channel 1 is sharp, when entering it, the water stream slowly narrows, detaches from the walls and creates a rarefaction zone. The space between the stream of water and the walls of the longitudinal passage channel 1 in the vacuum zone is also filled with water, which is in a rotary vortex motion at a pressure below atmospheric one. Through the radial holes 2, connecting the vacuum zone of the longitudinal passage channel 1 with the atmosphere, air is sucked in, which is intensively dispersed into water, thereby forming a water-air mixture. After that, the stream of the water-air mixture gradually expands and fills the entire section of the longitudinal passage channel 1 at the outlet. Further, the flow of the water-air mixture passes through the replaceable jet nozzle 4, due to which the liquid flow rate and the outlet pressure increase, thereby creating a greater vacuum and better water-air mixture dispersion. Then the jet, upon reaching the vertical flow spreader 7, is divided into two equal flows, the upper one, passing by the vertical flow spreader 7, is directed to the central part of the deflector, and the lower one, in turn, is divided into two more flows by the vertical flow spreader 7 and directed to deflector edges 5.
Figure 1. Deflector short-range nozzle.
All the parts of the divided water-air mixture flow hit the deflector 5, designed in the form of a curved surface and then, breaking against it in separate flows, form a common spoon-shaped solid stream. With further movement in the air, the water-air flows retain their continuity at a certain section of the path, but then they disintegrate and continue to move in the form of drops. Due to the flat platform 6, located between the replaceable jet nozzle 4 and the vertical flow spreader portion 7, it is possible to replace the replaceable jet nozzle with a similar one with other geometrical parameters.

Thus, the increase in the device manufacturability and the improvement in the artificial sprinkle quality indicators are achieved through the design of the body and the deflector by casting a single piece. At the end of the longitudinal passage channel 1, the internal thread is made into which a replaceable jet nozzle 4 with the diameter difference determined by the ratio 7/12 is screwed. On the deflector 5 there is a vertical flow spreader, designed in the form of a wedge assembly, its sharp part is directed toward the flow and has the angle of 15 ... 17º, the angle between the sides of the wedge assembly and the plane of the deflector is 90º, the wedge assembly sides heights are equal and form a surface parallel to the longitudinal passage channel, and its height corresponds to the longitudinal passage channel circumference center.

This technical solution allows to improve manufacturability and reduce the product cost, as well as to increase the uniformity of the spray, the range of sprinkle drops flow and the sprinkle gripping area.

4. Conclusion
The developed design of the deflector nozzle provides fine-drop sprinkle, which average diameter of the drops is 0.5 ... 0.7 mm, the range of sprinkle drops flow from the deflector jet nozzles is 4 ... 6 m/s. With such sprinkle, the energy impact on the soil and agricultural plants decreases, the bulk density in the upper soil layer and the mass of the sprayed soil decrease, which leads to the increase in crop yields by 6.0-20.0%.

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