Justification parameters in the fertilize coulter for local use of mineral fertilizing

Z L Batirov[1,*], I J Toirov[1] and Y E Makhmudov[1]

[1]Karshi engineering-economics institute, 225, Mustakillik ave, 180100, Karshi,Uzbekistan

Abstract.The article describes the design and technological process of the fertilizecoulter, which ensures the placement of fertilizers in two layers simultaneously with the formation of ridges and ensures uniform distribution of fertilizers to a given depth with a ribbon width, presents the scheme of the chisel cultivator fertilize coulter and the scheme of the fertilizewide with a three-way divider, and also justifies the parameters of the fertilizecoulter for local application of mineral fertilizers. In addition, the results of theoretical and experimental studies on the justification of the technology of fertilization and the development of a combined machine and a universal chisel cultivator - fertilizer are presented. A formula is proposed for determining the depth of the stroke of the tuck coulter, a formula for determining the diameter of the outlet of the collecting part of the tuck guide and the length of the guiding part of the tuck guide, and regression levels are given that adequately describe the uneven distribution of the fertilizer flow along the cross section of the tuck guide. Recommendations are given on the norms and methods of fertilization, depending on soil conditions.

Keywords: mineral fertilizers, cotton, chisel, fertilizer, coulter, comb, layer-by-layer application, yield.

1 Introduction

Technologies and technical means for applying mineral fertilizers to the development layer of the root system of plants is one of the important issues in the production of agricultural crops. Also, "... if we take into account that on a global scale the area of sowing crops on the ridges is 118 million hectares ...", then one of the important tasks in agriculture is the development of technical means for the formation of ridges with the simultaneous introduction of mineral fertilizers into the zone of development of the root system of plants. At the same time, much attention is paid to the development of combined machines that perform the technological processes of applying mineral fertilizers to the zone of the root system of plants during the preparation of the soil for sowing.

Domestic and foreign practitioners and researchers are conducting studies in the direction of developing promising resource-saving technologies for the formation of seeded

* Corresponding author: botirov1972@inbox.ru

ridges with simultaneous tiered application of mineral fertilizers under the ridges and technical means for carrying out this operation.

Based on these, this problem, that is, the justification of the technology and the development of a combined machine and a universal chisel cultivator-fertilizer with simultaneous fertilization and the formation of ridges is in demand and relevant.

In the production of agricultural crops, special attention is paid to reducing labor and energy costs, saving resources based on advanced technologies and the development of high-performance agricultural machines. In our case, there is a question of developing technical means that ensure high-quality performance of the main technological processes with minimal energy consumption when preparing fields for sowing due to the formation of ridges with simultaneous layer-by-layer fertilization.

The Action Strategy for the Further Development of the Republic of Uzbekistan for 2020-2030, in particular, outlines such tasks as "... an increase in the volume of gross domestic product by more than twice by 2030, ... rational use of land and water resources, the introduction of modern intensive agricultural technologies". To fulfill these tasks, one of the important issues is the technological and technical improvement of combined machines for the formation of ridges with simultaneous layer-by-layer fertilization.

Based on these studies, the proposed technology and technical means reduce the cost of cultivated crops by saving the consumption of mineral fertilizers.

Nitrogen, phosphorus and potash fertilizers are mainly used for cotton. All forms of nitrogenous fertilizers introduced into the soil, under the influence of microbiological activity in the soil, quickly turn into the highest form of nitrogen oxides into nitrates, which are highly soluble and move freely with irrigation water, migrating in soil layers. Under the action of irrigation water, nitrates are easily washed off into the lower layers of the soil beyond the limits of the physiological absorption center, and after evaporation of moisture from the upper horizons of the soil, their part, not assimilated by plants, is carried out to the uppermost non-root-inhabited soil layer, which leads to a significant decrease in the efficiency of using nitrogen fertilizers [2].

2 Materials and methods

It is known that many forms of phosphorus fertilizers, after applying them to the soil, completely or partially pass into a hardly soluble state and practically do not move with water. Therefore, it is advisable to apply phosphorus fertilizers to a depth with the most stable soil moisture regime in the area where the bulk of the cotton root system is located.

Research organizations have conducted numerous studies to establish optimal timing and doses of phosphorus fertilizers in various conditions of the republic [3, 4].

It has been established that the content of mobile forms of phosphoric acid in the soil with the joint application of nitrogen-phosphorus fertilizers in the soil remains significantly less than with the introduction of nitrogen or phosphorus fertilizers only. This is explained by the fact that with the joint application of plant nutrients, they are better used than with separate application [4].

The norms of phosphorus fertilizers depend on the state of saturation of soils with phosphates, i.e. on the presence of easily digestible phosphates in the soil. Summarizing the results of the work of research institutions, as well as agrotechnical experiments, rational norms for the application of nitrogen, phosphorus and potash fertilizers for cotton are recommended

The above recommendations of the fertilizer application rate, depending on soil conditions, will be taken into account by these studies when calculating and justifying the parameters of machines, devices and working bodies for local application and layer-by-layer distribution of fertilizers in the soil.

The effectiveness of fertilizers largely depends on the rate, time and method of their application.

Currently, the basic rate (60-70 annual) for cotton cultivation is usually applied in a scattered way for plowing. At the same time, fertilizers are mixed with a large volume of soil, which increases nitrogen losses, increases the transition of phosphorus and potassium to a less accessible state for plants. In addition, during plowing, fertilizers are placed unnecessarily deep and are not available to plants in the early phase of development.

The technology of cotton cultivation on the ridges has been known for a long time, but due to the lack of the necessary means of mechanization, it has not yet found a sufficiently wide application. Every year, the Chirchikselmash plant produces more than 1 thousand pieces of special comb makers GC-4, which ensure the formation of ridges with a distance between the furrows of 90 cm. Due to the lack of machines for local fertilization simultaneously with the formation of ridges, sometimes with comb technology fertilizers are applied in a spread under plowing before the formation of ridges.

In this case, after the formation of the ridges, a significant part of the fertilizers are carried out by furrow cutters to the surface and distributed along the slopes of the furrows, creating favorable conditions for the growth and development of early spring weeds.

From the above, it can be concluded that there is currently no device that ensures the placement of fertilizers in the zone of activity of the root system of cotton.

3 Result and Discussion

According to the above, the justification of the parameters of the fertilize coulter for local application of mineral fertilizers during the formation of ridges simultaneously in two layers is an urgent task. At the same time, the norm of seed fertilizer is introduced into the upper layer, and the norm of the main fertilizer is introduced into the lower layer, mainly with a wide ribbon.

To ensure the normal operation of the comb-maker with a device for fertilizing without unloading the soil in front of the working bodies and without slaughtering the soil and plant residues, it is necessary to justify the mutual arrangement of the fertilize coulters on the frame of the comb-maker relative to the furrows in the longitudinal and transverse directions.

The displacement of each fertilize coulter relative to the adjacent furrow in the transverse direction is due to the technological scheme and should be 0.5 of the width of the row spacing.

To ensure the placement of fertilizers in two layers simultaneously with the formation of ridges, a fertilize coulter device is proposed, which consists of a rack rigidly fixed to the chisel-cultivator frame 1 at the lower end of which a pointed paw 2 is installed, behind which a cone diffuser with a protective visor 3 is attached. Behind the rack there is a funnel 4 with a guide 5 and a three-way divider of the fertilizer flow 6. A tow pipe 7 is connected to the funnel, which is located along the axis of symmetry and is directed at the cone diffuser, also behind the tow pipe 7, two rigid curved tow pipes 8 are connected, the ends of which are symmetrically located on both sides of the symmetry line of the coulter in the transverse direction.

The end of each curved tow pipe is provided with a soil compactor 9 located at the bottom, a visor 10 mounted on top and side cheeks 11.

The fertilize coulter works as follows. The flow of fertilizers entering the funnel with the help of a guide is concentrated and directed perpendicular to the three-way divider, one of the fertilizer flows through the three-way divider enters the pipeline 7, and, hitting the cone diffuser, is located in a strip in the lower layer at the depth of the coulter stroke.

The soil, additionally loosened with a pointed paw, closes behind this fertilize wire and closes the fertilizer strip.

Two streams of fertilizers from the three-way divider are sent to curved pipelines 8. They are squeezed into the loose soil of the grooves, into which the fertilizer flows by gravity in two parallel lines. Furrow cutters located on the frame behind the fertilize coulters lift the soil from the furrows and place it on the top of the ridge, covering the top layer of fertilizers. Seals exclude clogging of the pipelines with loose soil from below, and visors and cheeks protect it from clogging with soil from above and from the sides.

To ensure the distribution of fertilizers into three streams, it is necessary to concentrate them, and direct the vertical flow to a "T"-shaped three-way dividing plate. This is dictated by the fact that the fertilize pipeline from the fertilize-raising apparatus (flexible fertilize pipeline) is often in an inclined position, while the flow of fertilizers feeding inside it shifts to one of its walls and the fertilizer is divided unevenly along the fertilize pipelines.

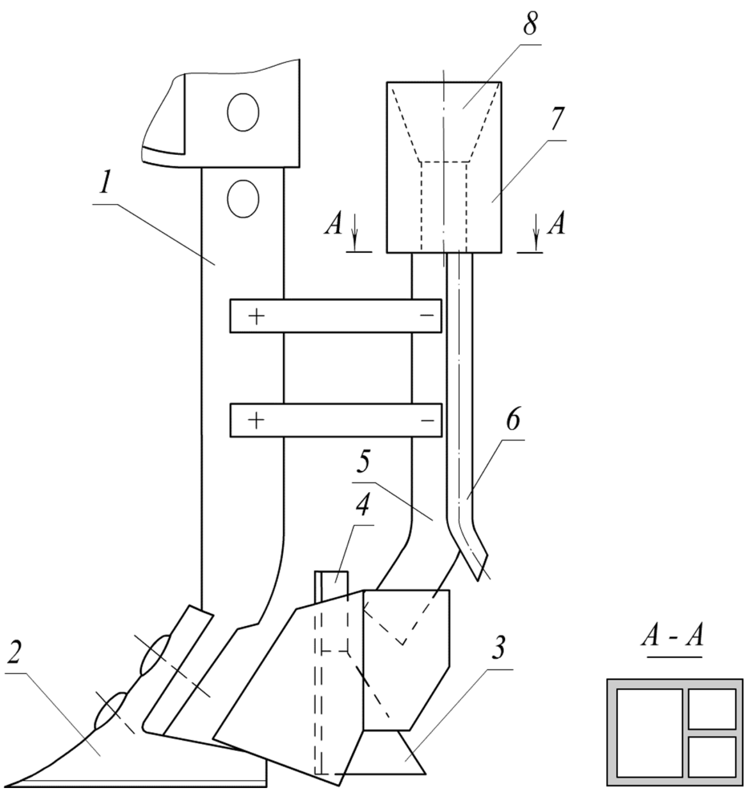

Fig. 1. Scheme of the chisel cultivatorsfertilize coulter

To ensure the supply of fertilizes with a concentrated flow, strictly vertically, on a "T"-shaped three-way divider, regardless of the position of the flexible fertilize pipeline in the coulter, a fertilize guide is installed directly above the three-way dividing plate, which consists of collecting 1 and guiding 2 parts (Fig.2.).

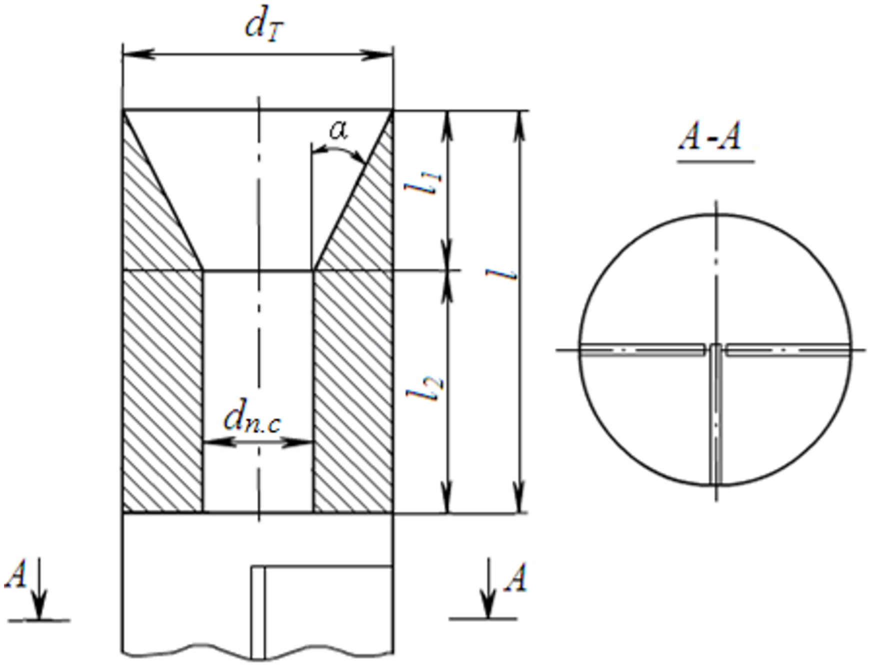

Fig .2. The scheme of the fertilize the guide with a three-way divider:
1– collecting part; 2– guiding part; 3 – three-way divider

At the same time, the norm of seed fertilizer is introduced into the upper layer, and the norm of the main fertilizer is introduced into the lower layer, mainly with a wide ribbon.

A Shadiev proposed A formula for determining the longitudinal distance between the toes of the fertilize coulter and the furrow cutter, which is determined by the longitudinal distance to which the deformation of the soil extends before the furrow cutters and the length of the fertilize coulter [6].

$$L_n \geq htg(\alpha_0^1 + \varphi_T) + l_2 \tag{1}$$

where h – is the depth of the furrow cutter; $\alpha_0{}^1$ – is the angle of entry of the furrow cutter; φ_T – is the angle of friction of the soil on the surface of the furrow cutter, º; L_2 – is the length of the fertilize coulter.

Calculations according to the formula showed at L_2 =32 cm, h=17 cm, $\alpha_0{}^1$ =16, φ_T=31º, L_n≥479 mm.

To ensure the placement of fertilizers of the upper and lower tiers in accordance with the agro technical requirements regarding the top of the ridge, a formula is proposed to determine the depth of the stroke of the fertilize coulter

$$h_{tc} = h_0 + d - \frac{2h^2 ctg\theta}{m_0 + c - 2hctg\theta} \tag{2}$$

where h_{tc}– is the depth of fertilization of the upper layer relative to the top of the ridge; d – is the distance between the seeding windows of the upper and lower fertilize pipelines of the fertilize coulter; θ - is the angle of the natural slope; m – is the distance between the furrows; c – is the width of the ridge along the top.

Calculations using the formula (2) showed that the best depth of the furrow cut is h = 17 cm.

Parameters such as the angle of inclination of the forming collecting part to the vertical, the diameter of the output section of the collecting part and the length of the guide part affect the operation of the fertilizeguide.

According to this, the angle α_c from the slope of the generation to the vertical of the collecting part of the fertilizeguidecan be taken equal to 13-18.

It is known that the diameter of the outlet of the collecting part of the fertilizeguideshould be taken as small as possible, but providing a condition for the free passage of fertilizers through the fertilizeguide, depending on the seeding rate.

Based on the fertilizer seeding rate, taking into account the speed of the pellet falling inside the fertilize wide and the translational speed of the comb-maker. A Shadiev [6] offers A formula for determining the diameter of the outlet of the collecting part of the fertilizeguide

$$d_{cr} = 2\sqrt{\frac{0{,}1Qm_0V_n}{\pi V_y\gamma_n}} \tag{3}$$

where Q – seeding rate, kg /ha; m_0 – row spacing, m; V_n – translational speed of the comb-maker, m/s; V_y– the rate of fall of the fertilizer granules, m/s; γ_n – fertilizer density, kg/m.

Calculations using the formula (1.3) showed that, at a rate of Q =350 kg/ha and V_n= 2 m/s and γ_n=1950kg/m^3, the diameter of d_{cr} = 35.4 mm.

For the normal course of the process, the fertilizer granules, when moving after leaving the outlet of the collecting part of the fertilizeguide, should not hit the opposite wall of the directing part. From this condition, we determine the length of the guide part of the fertilizeguideby the formula

$$b_2^{\,1} > d_{cr}\left\{\frac{gd_{cr}}{2\left[V_{01}^2 + g(d_T - d_{cr})(ctg\alpha_c - f)\sin^2\alpha\right]} + ctg\alpha_c,\right\} \tag{4}$$

where V_{01} – is the velocity of the fertilizer particle along the inclined surface; d_T – is the inner diameter of the flexible pipe line; f – is the coefficient of internal friction of the fertilizer; g –is the acceleration of free fall.

Calculations using the formula (1.4) showed that, at V_{01}=3.24 m/s, α_c=13-18º, d_T=0,05 m, f=0.48, the length of the guide part of the fertilizeguide$l_2^{\,1}$=0.11-0.16 m.

As a result of the research, it was found that the uneven separation of fertilizers into three streams increases with the slopes of the flexible fertilize pipeline. At the angles of inclination of the flexible fertilize pipeline from 5 to 200, the unevenness between the fertilize pipelines of the upper and lower layers increases from 2.7% to 80-90%, and between the two fertilize pipelines of the upper layer from 20% to 65% or more [7, 9].

Hence the need to install a fertilizeguide consisting of collecting and guiding parts.

Using the method of mathematical planning of the experiment, the parameters of the fertilizeguidewere optimized.

After processing the results of the experiment on a computer, a regression equation was obtained that adequately describes the uneven distribution of the fertilizer flow along the cross-section of the fertilizeguide.

$$Y=9.089-0.33X_1+0.487X_1^2+1.6X_1X_2+4.29X_2^2,\%. \tag{5}$$

The analysis of equation (5) shows that the unevenness of the separation of the fertilizer flow is most influenced by the angle of inclination $\alpha_c$of the forming part, with an increase in which the unevenness decreases.

After solving the regression equation on a computer, the optimal values of the parameters of the fertilizeguide were obtained:α – the angle of inclination of the forming collecting part α=17º, the length of the guide part L=120 mm.

4 Conclusions

To ensure uniform distribution of fertilizers over the width of the strip, the coulter diffuser is made of a half-funnel and a half-cylinder fixed tolerably to each other and to a flat partition. At the same time, the feeding part of the fuel line is installed at an angle to the axis of the diffuser.

Theoretical studies have established that for better concentration and uniform supply of fertilizers to the semi-cylinder, when the fertilizer granules move along the inner surface of the cylinder with sliding, the angle of inclination and the height of the feeding part should be, respectively, 65 and 80 ...85 mm, and with abrupt movement, respectively, 70 and 97-120 mm. [18, 19, 21]

Studies of the distribution of fertilizers along the width of a fertilize coulter with a cone diffuser have shown that our proposed device of the diffuser ensures the uniformity of the distribution of fertilizers within the limits allowed by agricultural requirements. When the fertilizer granules move along the surface of the half-funnel with sliding, the unevenness is 8.98%, and when the movement is abrupt, it is 17.6%. To ensure uniform separation of fertilizers between tiers, a three-way divider with a fertilizeguide has been developed, which consists of collecting and guiding parts. At the same time, to ensure high-quality separation of fertilizers, the angle of inclination of the forming collecting part α_c=17° and the length of the guide part L_2 = 120 mm. [22, 23, 24]

By the method of mathematical planning of the experiment, the relationship between the main parameters of the fertilize coulter and its traction resistance and the depth of fertilization of the upper layer was established. At the same time, with an agrotechnical permissible value, the depth of the fertilization of the upper layer (Y_2=150-170mm), having a minimum value of the traction resistance of the coulter, the following parameters of the coulter are accepted: β=35°, ν'=45, V_0= 1.4-2.0 m/s.

References

1. Batirov Z, Toirov I, Boymuratov F. and Sharipov Sh Layered application of mineral fertilizers with the coulter ripper of a combined unit 2021 *IOP Conf. Series:Materials Science and Engineering*1030, 012168
2. Batirov Z, Razzakov T, Begimkulov F. and Boymuratov F. Traction resistance of a ripper with a current distribution line. 2021 *E3S Web of Conferences*264, 04051
3. Toirov I., Batirov Z. and Sharipov E. Theoretical prerequisites for improving durability of fixed rolling bearing joints restored with anaerobic. *E3S Web of Conferences*365, 04020 (2023)
4. Batirov Z., Toirov I. and Razzakov T. Technology of ridge formation on cotton fields with simultaneous fertilization. *E3S Web of Conferences*365, 04008 (2023)
5. Maiviatov F, Karshiev F, Gapparov Sh Movement of crushed stem particles when they interact with hammers, *IOP Conf. Series: Earth and Environmental Science*868012060 (2021).
6. Shadiev A.R. Substantiation of the parameters of the fertilizers coulter for local application of mineral fertilizers during the formation of ridges. Abstract, Yangiyul, 1994,-18 p.
7. Mamatov F, Umurzakov U, Mirzaev B, Eshchanova G, Avazov I.Traction resistances of the cotton seeder moulder, *E3S Web of Conferences* 264 04065 (2021).
8. Kholikova N, Khakimov B, Alikulov S, Ravshanova N, Mambetsheripova A 2021 *E3S Web of Conferences* 264, 04043
9. Aldoshin N.V., Mamatov F.M., Kuznetsov Yu.A., Kravchenko I.N., Kupreenko A.I., Ismailov I.I., Kalashnikova L.V. Loosening andleveling device for preparing soil for

melon, INMATEH - Agricultural Engineering appearing in print (ISSN 2068 – 4215) and on-line (ISSN2068 – 2239)Vol. 64, No. 2 / 2021.
10. Hamroyev O, Ravshanova N, Jovliyev V and Komiljonov S 2021 E3S Web of Conferences 264, 04052
11. RavshanovH, BabajanovL, Kuziev Sh, RashidovN, KurbanovSh*IOP Conf. Series: MaterialsScienceandEngineering* 883 012139
12. Tulaganov B, Mirzaev B, Mamatov F, Yuldashev Sh, Rajabov N, Khudaykulov R F. Machines for strengthening the fodder of arid livestock, *IOP Conf. Series: Earth and Environmental Science* 868 012062 (2021)
13. Mirzaev B, Ergashov G, Maiviatov F, Ravshanova N, Toshtemirov S and Begimkulova M 2022*IOP Conf. Series: Earth and Environmental Science* 1076 012022
14. Mamatov F, Mirzaev B, Toshtemirov S, Hamroyev O, Razzaqov T and Avazov I2021*IOP Conf. Series: Earth and Environmental Science* 939012064
15. Mamatov F, Aldoshin N, Mirzaev B, Ravshanov H, Kurbanov Sh and Rashidov N 2021*IOP Conf. Series: Materials Science and Engineering*1030, 012135
16. Tulaganov B, Mirzaev B, Mamatov F, Yuldashev Sh, Rajabov N and Khudaykulov2021 *IOP Conf. Series: Earth and Environmental Science*868012062
17. Mamatov F, Mirzaev B, Berdimuratov P, Aytmuratov M, Shaymardanov B and Jumamuratov D2021*IOP Conf. Series: Earth and Environmental Science*868012052
18. Iroda Babazhanova, Yuldash Babazhanov, Orifjan Bazarov, Sobir Eshev and Shaxboz Latipov. Fluid movement in a flat pipe with a break. E3S Web of Conf. Volume 365, 2023. Engineering" (CONMECHYDRO - 2022). Article Number 03042
19. Eshev S. Latipov Sh. Qurbonov A. Berdiev M. Mamatov, N. Non-eroding speed of water flow of channels running in cohesive soils. IPICSE 2020 IOP Conf. Series: Materials Science and Engineering 1030 (2021) 012131IOP Publishing https://doi:10.1088/1757-899X/1030/1/012131
20. Aldoshin, N., Mamatov, F., Ismailov, I., Ergashov, G. Development of combined tillage tool for melon cultivation // 19th international scientific conference engineering for rural development Proceedings, Jelgava, 20.-22.05.2020. Volume 19. ISSN 1691-5976. DOI:10.22616/ERDev.2020.19.TF175.
21. Eshev S. Latipov Sh. Qurbonov A. Berdiev M. Mamatov, N. Non-eroding speed of water flow of channels running in cohesive soils. IPICSE 2020 IOP Conf. Series: Materials Science and Engineering 1030 (2021) 012131IOP Publishing https://doi:10.1088/1757-899X/1030/1/012131
22. Latipov Sh. Gayimnazarov I. Babajanova I Eshev S. Babajanov Y. Shodiev, B. Calculation of bottom sediment discharge in trapezoidal channels. E3S Web of Conferences 264, 03070 (2021) https://doi.org/10.1051/e3sconf/202126403070 CONMECHYDRO-2021
23. Alisher Mallayev**,** Jasur Sevinov**,** Suban Xusanov**, and** Okhunjon Boborayimov**.** Algorithms for the synthesis of gradient controllers in a nonlinear control system. AIP Conference Proceedings 2467, 030003 (2022); https://doi.org/10.1063/5.0093749
24. Mallaev A.R., Xusanov S.N., Sevinov J.U. (2020). ALGORITHMS OF NONPARAMETRIC SYNTHESIS OF DISCRETE ONE-DIMENSIONAL CONTROLLERS. International Journal of Advanced Science and Technology, 29(5s), 1045-1050. Retrieved from http://sersc.org/journals/index.php/IJAST/article/view/7865