Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 1 (2024)

Direct Spreading Machine

Aydin Yunis[1], Rana Uzeyir[2], Leyla Aydin[3], Vahid[4], Aysel Sarvar[5]

[1]*PhD in technology, associate professorIsayev;*

[2]*PhD in technology, associate professorOrujova;*

[3]*Head teacher Ramazanova;*

[4]*Assistant , Pashayeva Rukhsara Assistant Bayramova*

[5]*Azerbaijan State Agrarian University,Ganja, Azerbaijan*

Abstract.Mechanical tillage of the soil is considered a powerful factor in regulating its fertility. Long-term intensive cultivation of the soil leads to mineralization of organic matter. The application of highly intensive land cultivation systems in agriculture has been one of the reasons for weakening soil fertility. At this time, it should also be taken into account that 40% of the energy consumption for the cultivation of agricultural plants, and 25% of the labor consumption according to the total volume of work, falls on soil cultivation.

In this regard, it is of great importance to search for ways to minimize the main cultivation of the soil without reducing the productivity of the plant. From this point of view, technologies of minimum and zero tillage of the soil in the sowing of grain and grass are taking their place as promising technologies in the world experience. However, the development of this method, whether in terms of technological or technical support, is currently experiencing the phase of comprehensive study of its individual issues. Our research in this direction has shown that the successful implementation of direct seeding technology, either for grain in the harvested field or for grass seeding in grasslands to improve the fodder base, depends on the level of scientific justification of the seeding machine. From this point of view, it is very relevant to build a dynamic model of the sowing machine for direct sowing of grain.

Key words:*direct seeding, seeding machine, dynamic characteristic, dynamic model, oscillatory system, kinetic energy, potential energy, distribution function.*

Аннотация.Отмечается преимущества нулевой обработки почвы и важность оценки качества высева при прямом посеве. Ставится цель обосновать условия качественного расположения семян в поле на основе математической модели процесса. Рассматриваются несколько моделей процесса расположения семян в рядке. Построена графическая зависимость, характеризующая коэффициент вариации интервалов между растениями в зависимости от полевой всхожести семян при разной точности высева. Вариант идеальной точности высева, то есть имеющий наилучший результат может служить оценочным при выборе существующей или при проектировании новой техники. Представлены формулы, описывающие интервалы между семенами.Установлено, что у последовательностей семян в рядке и у моделей этих последовательностей свойства автокорреляционных функций и спектров хорошо согласуются. Получены формулы описывающие интервал между семенами позволяют на основе вероятности на высева семян аппаратом определить вероятностные характеристики интервалов между семенами при работе посевной машины прямого посева.

У последовательностей семян в рядке и у моделей этих последовательностей свойства автокорреляционных функций и спектров хорошо согласуются. У последовательностей растений в рядке и у рассмотренных моделей этих последовательностей свойства автокорреляционных функций и спектров не одинаковы. В то же время единственное различие этих последовательностей –наличие не взошедших семян, а единственное дополнительное ограничение, к которому мы прибегли при составлении модели рядка растений – постоянство величины полевой всхожести.

Ключевые слова:*Посев, качество посева, посевная машина, всхожесть, вероятностная модель, коэффициент вариации, плотность вероятности.*

Для цитирования: Самуилов К.Э., Шалимов И.А., Кулябов Д.С. Сети и системы передачи информации: Сети телекоммуникаций: Учебник и практикум для академических бакалавров.-М.: Издательство 2017.

Research Object And Method

As a research object, the seeding unit and its working body, which ensure the optimal placement of grain seeds under the soil according to the nutrient area, were selected. The study is based on mathematical analysis using machine mechanisms and laws of soil mechanics. The dynamic properties of the whole system and individual elements were analyzed at each stage. The design of the model is based on the static dynamics of agricultural machines, mathematical expressions reflecting the movement of mobile units [5, 6].

Research Results And Their Discussion

The sprinkler unit, being a complex controlled dynamic system, continuously operates under conditions of changing external influences. These effects are caused by many different factors. Various and especially random factors manifest themselves in the technological and energetic indicators of the machine and uneven loading of the tractor.[1, 2, 3,4].

The direct seeding machine behaves like a multidimensional dynamic system in real working conditions. It includes input effects and output parameters as $(\overline{Y})$external $(\overline{X})$and internal factors. $(\overline{F})$The dynamic model of the machine and its simplified form are given in Fig. 1.

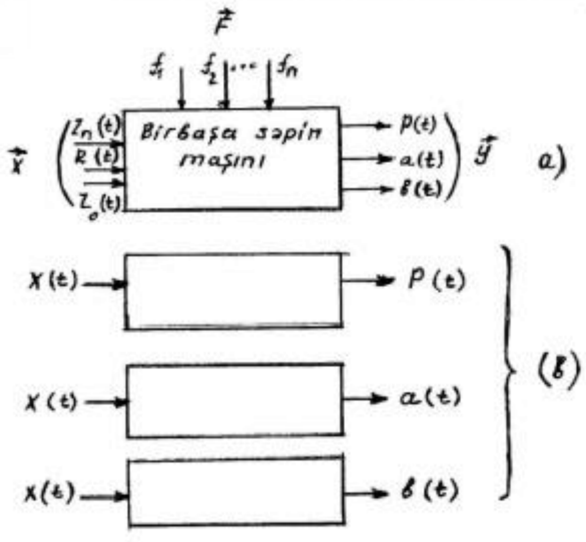

Fig. 1. Dynamic model of direct seeding machine (a) and itssimplified models (b).

If we look at the operation of the machine as its reaction to the input effects and denote the output parameters by vectors, and the external and internal parameters by and respectively, we can write the general mathematical model of the machine according to the "input-output" principle $\vec{y} = [P(t), a(t), b(t)]$ as $\vec{X} = [Z_n(t), R(t), Z_o(t)]$ follows $\vec{F} = (f_1, f_2, .., f_n)$:

$$\vec{y} = A(\vec{F})\vec{X}, \qquad (1)$$

here $A(\vec{F})$ - the operator of the system, from the internal parameters of the machine

it depends.

consists of defining the operator A. It defines the algorithm for converting external effects into output parameters. The structure of the operator of the direct seeding machine depends on its structural scheme and the values of internal parameters (geometric dimensions, stiffness, mass, etc.).

External indicators from the working environment: Z(t) – unevenness of the field surface , R(t) unevenness of soil resistance, – $Z_o(t)$ the vector represents the effect of tractor shaking (dances) . $\vec{X} = [Z(t), R(t), Z_o(t)]$ The output indicators of the machine are $\vec{y} = [P(t), a(t), b(t)]$ characterized by the vector. Here $P(t)$ - the draft resistance of the sowing machine, $\alpha(t)$ - the depth of seed burial, $b(t)$ the width of seed spreading in the row.

Taking into account the multidimensional nature of the dynamic system, the following estimates were adopted during the study:

- the unit moves in a straight line at a constant speed;

- the deviation of the car from the fixed position is small, not to be taken into account

can;

- transition process when the established regime is disturbed by any factor

as soon as the dynamic system is exhausted, it takes a new steady state;

- due to the deviation of the trajectories of aggregate points

as external forces and moment changes with these inclinations and theirs

are directly proportional to their derivatives.

the direct seeding machine as a dynamic system for the equal distribution of seeds on the area and depth, it is possible to give its full value by looking at its movement in the horizontal-vertical plane.

Taking into account the received estimates, the reporting scheme of the sowing machine in the transverse-vertical plane is shown in Fig. given in 2.

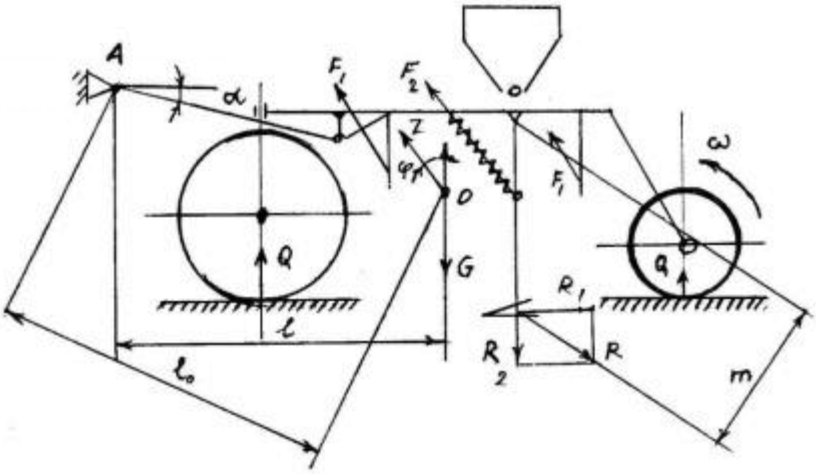

Fig. 2. Direct sowing machine reporting scheme.

Under the influence of the resistance force (R) in the real working conditions of the sprinkler machine, it wants to get a new steady state in the transverse-vertical plane. When the relief of the field, the property and the mass of the seed in the hopper change, the resistance force changes in direction as well as in modulus and causes the machine's coulters to oscillate.

is subject to displacement in the vertical direction Z_0 and an additional oscillating motion relative to the center of resistance along the -coordinate. φ Since the displacement in the vertical direction is small, it can move to angular oscillations due to the joint (A) of the tractor, which is connected to the trailer of the tractor.

$$Z_o = \ell = \alpha, \qquad (2)$$

here α – angular oscillations of the trailer of the direct seeding machine with respect to the tractor.

The generalized coordinates (φ and α) chosen in this way can be used to construct the equation of motion of the machine.

With the accepted estimates, the movement of the mobile unit can be expressed in the simplest way with the help of Lagrange's equation of the second order [7]:

$$\frac{d}{dt}\left(\frac{\partial T_k}{\partial q_i}\right) - \frac{\partial T_k}{\partial q_i} + \frac{\partial \Pi}{\partial q_i} + \frac{\partial \Phi}{\partial q_i} = Q_i(t), \qquad (3)$$

where T is kinetic energy, Nm;

Π – potential energy, Nm;

Φ – distribution function Nm;

$Q_i(t)$ is the force applied over time, N.

To obtain the equation of motion of the sprinkler machine, we write the equations of the kinetic (T), potential (Π) energies and the distribution function:

$$T = \frac{1}{2}(J_1\dot{\varphi}^2 + J_2\dot{\alpha}^2) \qquad (4)$$

$$\Pi = \frac{1}{2}(C_1\dot{\varphi}^2 + \dot{\alpha}^2) \quad (5)$$

$$\Phi = \frac{1}{2}(b_1\dot{\varphi}^2 + b_2\dot{\alpha}^2) \quad (6)$$

where J_1, J_2 – the inertia of the machine on φ and α coordinates, respectively

are moments, Nm sec ^{2};

C_1, C_2 - "machine - land"stiffness coefficients of the system or of the machine

to its previous position on the generalized coordinates (φ and α).

coefficients that take into account the ability to return, Nm/rad.

b_1, b_2 – of the machine on φ and α coordinates , respectively

coefficients that take into account the resistance to change of state,

N seconds/rad.

Differentiating expressions (4), (5) and (6) according to generalized coordinates and using them in equation (3), we get the following equation of motion of the machine with some transformations:

$$J_1\frac{d^2\varphi}{dt^2} + b_1\frac{d\varphi}{dt} + C_1\varphi = [F_1(t) + F_2(t)] \cdot \ell; \quad (7)$$

$$J_2\frac{d^2\varphi}{dt^2} + b_2\frac{d\alpha}{dt} + C_2\alpha = [F_1(t) + F_2(t)] \cdot \Delta\ell, \quad (8)$$

where $F_1(t)$ is the impact force caused by the change in the relief of the land surface,

N;

$F_2(t)$ – the impact force caused by the change of soil properties, N;

ℓ_o – influence arm of the force generated on the φ coordinate, m;

$\Delta\ell$ – arm of the force created on the α coordinate, m.

When we write the values of the coefficients in equations (7) and (8) and divide all sums of the equation by the coefficients in φ and α , we get the transfer function of the machine in the form of the following operator:

$$W_{(p)} = \frac{k\left(t_4^2P^2 + t_3P + 1\right)}{t_6^4P^4 + t_5^3p^3 + t_1^2P^2 + t_2p + 1}, \quad (9)$$

here $p = \frac{d}{dt}$ – symbol of differentiation;

t_i – time constant;

$W_{(p)}$ - the operator.

Under zero initial conditions, the operator form (9) is as follows with the sign of the variables according to Laplace:

$$W_{(s)} = \frac{k\left(t_4^2 S^2 + t_3 S + 1\right)}{t_6^4 S^4 + t_5^3 S^3 + t_1^2 S^2 + t_2 S + 1}, \qquad (10)$$

here $W_{(s)}$ – is the transmission function of the seed drill.

the dynamic characteristics of mobile agricultural machines working at small frequencies, prof. ABLurye [5] recommends a simpler expression of the transfer function:

$$W_{(s)} = \frac{k(t_3 S + 1)}{t_2^2 S^2 + t_1 S + 1} \qquad (11)$$

When determining t_i and k from equation (11) , the damping coefficient (ε) characterizing the oscillation of the system is determined as follows:

$$\varepsilon = \frac{t_2}{2t_1}. \qquad (12)$$

The generalized integral criterion (J_v) is used to evaluate the dynamic property of the direct seeding machine:

$$J_v = \frac{k^2}{2t_1}[(t_3 - t_1)^2] + t_2^2 + \left(\frac{t_3}{t_1}\right)^2 + 1. \qquad (13)$$

By conducting a theoretical analysis of the dynamics of the direct sowing machine in the transverse-vertical plane, it can be noted that it is possible to determine the degree of oscillation (shaking) of this oscillating system by the integral criterion(J_v).

Conclusion

The dynamic characteristic defined by equations (7) and (8) demonstrates how the direct seeding machine will behave in transient processes (when field effects change). The study and analysis of the dynamic properties of the entire system and its individual parts at each stage can be used to choose a rational control scheme of the technological process during the operation of the machine and to justify the constructive-technological parameters for improving the working bodies .

Summary

The relevance of soil protection and energy saving technologies in agriculture is noted from the standpoint of preserving soil fertility and increasing crop yields. In this regard, special attention is paid to the use of direct sowing and, first of all, to the study of sowing equipment, which is the main technical means in the implementation of this technology. In this regard, the article reflects the results of research on the construction of a dynamic model of a direct seeding seeder and a theoretical analysis of its behavior in field conditions. Based on the work carried out and a theoretical analysis of the dynamics of a direct seeding drill in the longitudinal-vertical plane, design equations were obtained that make it possible to determine the degree of oscillation of the system through an integral criterion.

Резюме

Отмечается актуальность почвозащитных и энергосберегающих технологий в земледелии с позиции сохранения плодородия почв и повышения урожайности сельскохозяйственных культур. В этом отношении особое внимание уделяется на применению прямого посева и в первую очередь исследованию посевной техники, являющийся основным техническим средством в осуществлении указанной технологии. В связи с

этим в статье отражается результаты исследований по построении динамической модели сеялки прямого посева и теоретический анализ поведение её в полевых условиях. На основе проведенной работы и теоретического анализа динамики сеялки прямого посева в продольно –вертикальной плоскости получены расчетные уравнения, позволяющие определить степень колебательности системы через интегральный критерий.

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УДК 631.331

ПОСТРОЕНИЕ ДИНАМИЧЕСКОЙ МОДЕЛИ СЕЯЛКИ ПРЯМОГО ПОСЕВА

Д.ф.т., доцент Исаев А.Ю

Азербайджанский Государственный Аграрный Университет

Р Е З Ю М Е

Отмечается актуальность почвозащитных и энергосберегающих технологий в земледелии с позиции сохранения плодородия почв и повышения урожайности сельскохозяйственных культур. В этом отношении особое внимание уделяется на применению прямого посева и в первую очередь исследованию посевной техники, являющийся основным техническим средством в осуществлении указанной технологии. В связи с этим в статье отражается результаты исследований по построении динамической модели сеялки прямого посева и теоретический анализ поведение ее в полевых условиях. На основе проведенной работы и теоретического анализа динамики сеялки прямого посева в продольно –вертикальной плоскости получены расчетные уравнения, позволяющие определить степень колебательности системы через интегральный критерий.

Ключевые слова:*прямой посев, сеялка, динамическая характеристика, динамическая модель, колебательная система, кинетическая энергия, потенциальная энергия, функциятраспределения.*