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Theory of oscillation excavation of root crops of beets saccharine

Aim. To work out the substantive provisions of theory of oscillation excavation of root crops of beets saccharine on the basis of consideration of shock co-operation of excavation of working organ with the body of root crop of beet that is contained in soil, and to get on their basis the parameters of process, that will provide the undamage of root crops. Methods. Analytical researches of oscillation excavation of root crops of beets saccharine are carried out on the basis of mechanico-mathematicaldesign of process, in particular theories of mechanical blow. Results. The theory of shock co-operation of excavation ploughshares of oscillation digger is worked out with the body of root crop of beet saccharine at his asymmetric delight. Analytical expressions of frequency of vibrations of excavation ploughshares, at that the terms of undamage of body of root crop are executed are got. The numerical decision of got on PEC of equalizations gave an opportunity to define the structural and kinematics parameters of oscillation excavation of working organ, at that there is not a damage of bodies of root crops of beets saccharine for their excavation from soil. Conclusions. The equivalent chart of oscillation excavation of root crop of beet saccharine is worked out on the basis of consideration of shock co-operation of body of root crop with a ploughshare, when the delight of root crop takes place asymmetric, id est their contact comes true only in one point, taking into account all forces that arise up at such contact. On the basis of general theory of blow the theory of oscillation excavation of root crop of beet saccharine is created from soil for terms, when shock co-operation does not cause the damages of bodies of root crops of beets. A numerical decision on PEC of the got analytical dependences gave an opportunity to define possible frequencies of vibrations of oscillation excavation of working organ.

Key words: beet, root crop, excavation, vibrations, equivalent chart, mathematical model, shock impulse, amplitude, frequency.

The technological process of oscillation excavation of root crops of beet saccharine got distribution in many бурякосіяльних countries of the world. Long-term experience of the use of this process showed that he had a row of advantages comparatively with another ways of excavation. Therefore exactly this technological process requires the further detailed analytical research that will ground for development of more perfect oscillation excavation of working organs.

Raising of problem. For implementation of technological process of collection of beets saccharine necessary terms are providing of the productivity, decline of energyexpenses and upgrading of the collected products. In relation to beet-lifting machines - the main condition of providing of quality of implementation of technological process foremost is an undamage of root crops at their direct excavation from soil. Fully obviously, that most probability of damage of root crops of beets is at presence of the shock co-operating of excavation of working organ of beet-lifting machine with the body of the root crop actually envisaged in soil. Therefore there is a necessity in theory to investigate the mentioned shock co-operation and on the basis of the got results to define the kinematics and structural parameters of oscillation excavation of working organs that would provide the terms of undamage of root crops of beets saccharine for their excavation from soil.

Analysis of the last researches and publications. Fundamental theoretical researches of process of oscillation excavation of root crops are represented in labours [1-5, 9, 10]. However shock co-operating of oscillation excavation organ with the body of root crop of the beet envisaged in soil, not examined here. Only

in works [6, 7, 13, 14] some experimental results over of shock co-operation of pendulum копіра are brought with the head of root crop. Therefore in this work the process of oscillation excavation of root crop is investigated on the basis of consideration of shock co-operation of oscillation excavation of working organ with the body of root crop of beet in the moment of his direct quick visit on a root crop and next asymmetric delight. As an analysis of foreign literature testifies [15-18], from soil considerable attention is spared the quality indexes of excavation of root crops of beets saccharine.

Aim of researches - to work out the substantive provisions of theory of oscillation excavation of root crops of beets saccharine on the basis of consideration of shock co-operation of excavation of working organ with the body of root crop that is contained in soil, and to get on their basis the parameters of process, that provide the undamage of root crops.

Materials and methods of researches. For implementation of analytical research of process of oscillation excavation of root crop of beet saccharine from soil a mechanics and mathematics method, that is based on the construction of mathematical model of process with the use of theory of vibrations, general theory of mechanical blow and other laws of mechanics, is applied.

Results of researches. Will consider technological and physical and mechanical terms in that there is a process of oscillation excavation of root crops of beets from soil at first. As root crops of beets of the saccharine in relation to the axis of line sowing are often enough placed with some transversal rejection, then quite often can take place shock co-operation of root crop from digging up by a working organ in one point, id est with one of excavation ploughshares (wedges).

In addition, for approaching of oscillation excavation of working organ to the root crop of beet loosening soil between ploughshares and root crop as a result of vibrations of ploughshares does not almost accumulate, and that is why the first contact of ploughshares with the surface of root crop will be direct or, at least, through the skim enough of soil. Thus, at the quick visit of ploughshares of excavation of working organ on the root crop of beet there is a blow, that, as known, is characterized by a considerable shock impulse. As a shock impulse has an eventual value is certain, and he operates on the very short interval of time, then crushing power here is large enough and substantially exceeds the values of all other forces, that in this moment operate on a root crop. As a root crop yet is firmly envisaged in soil, then there is a threat of his breaking off or break.

Obviously, that breaking off or break of root crop is more credible, when a root crop is envisaged in hard and dry soil, that is why exactly this situation needs to be investigated. Foremost will lay down the equivalent chart of shock co-operation of oscillation excavation of working organ with the body of root crop at the direct quick visit of working organ on a root crop. For this purpose will give an oscillation working organ as two wedges and, each of that in space has inclination under corners,, . These wedges are set to each other so, that a working river-bed the back-end of that narrows (rice. 1) appears. The marked wedges carry out fluctuating motions in a longitudinally-vertical plane (direction of forward motion of oscillation excavation of working organ is shown by a pointer).

Will consider that shock co-operation of root crop that is approximated by the body of cone-shaped form takes place only with the surface of wedge in a point (see rice. 1). Thus a shock contact can take place or directly or through the skim of soil between the surface of wedge and root crop of beet.

For description of shock process it is needed carefully to line up a power chart and choose the system of coordinates. Will bind to oscillation digging up a working organ rectangular cartesian system of coordinates of Oxyz, center Oh that contained in the meadle of the narrowed river-bed of digger, axis Oh coincides with direction of forward motion of digger, the axis of Oz has direction upwards, and the axis of Oy is directed in the right side of digger (see rice. 1). Will show forces that arise up as a result of co-operating of oscillation working organ with a root crop.

Let vertical збурювальна force that changes on a harmonic law and operates from an oscillation working organ, as she is passed from both wedges, then on an equivalent chart she is marked two by constituents and, that is added accordingly in points and in the distance h from the conditional point of fixing of root crop in soil of O1. That is why have such correlation:

, (1)

where ? amplitude of збурювальної force, H; ? колова frequency of збурювальної, c-1.

Rice. 1. An equivalent chart of oscillation excavation of root crop of beet saccharine is at a shock contacti

As oscillation копач moves forward in direction of axis Oh, then in direction exactly of axis Oh motive forces operate also and, reported in points and accordingly. In addition, force of friction, that counteracts to проковзуванню of root crop on the working surface of wedge, operates in the point of direct contact also . Force of weight of root crop operates in the center of weight of root crop (point of C) . Сили of connection of root crop with soil in direction of axes Oh, it is marked through Oy and Oz, and accordingly. And in the end, during a blow on the root crop of beet the shock impulse reported in a point operates from the side of oscillation excavation of working organ . This shock impulse is directed along a normal to the working surface of ploughshare, id est planes [11].

In addition, a tangent shock impulse operates for the surfaces of wedge . According to the hypothesis of Payca, connection between sizes tangent and normal shock impulses formulated like the law of Coulomb for a friction [12], id est . Thus ? it is a dynamic coefficient that characterizes properties of surfaces of bodies, that співударяються. On the whole this coefficient can not coincide with the coefficient of friction at безвідривного relative проковзування of bodies. The sign of inequality belongs to the case, when a tangent impulse is so small, that проковзування of bodies does not take place. And only at presence of проковзування it is needed to accept equal sign.

Farther will decompose an impulse on a constituent perpendicular to the line, and constituent parallel to the line (see rice. 1), id est, . Thus is obvious, that a corner between a constituent and vector in the first approaching depends on a relation . The presented vector will give an opportunity in further to find his projections on the axes of Ox, Oy and Oz.

A size of shock impulse can be different depending on the rate of a shake movement of working organ in a vertical plane in the moment of his quick visit on a root crop. In addition, as a root crop has a conical shape, then at motion of oscillation working organ the vertical constituent of shock impulse is actually absent downward. In this case a shock impulse will arise up only from forward motion of digger.

Will investigate fluctuating motion of oscillation excavation organ more detailed. Let a working organ move upwards from the most subzero position - "-" to the greatest position "", where is amplitude of vibrations of working organ, and then downward - from the greatest position "" to most subzero - "-". Thus the vibrations of oscillation excavation of working organ must come true on a harmonic law: at deviation of working organ from a horizontal axis round that there is oscillation, and to коловій frequency of vibrations of working organ. Then the rate of a shake movement of working organ will equal in any moment of time of t, and her maximal value will be .

Thus, it is needed to investigate shock co-operation, when a shock impulse will be maximal. It is an exactly that case, when in the moment of quick visit of oscillation excavation organ on a root crop a working organ moves upwards at full pelt .

As all forces represented on rice. 1, have eventual sizes, then in times of blow impulses from these forces will be near to the zero. Only shock impulses will have unzero values.

Farther will apply a theorem about the change of amount of motions during a blow [12]:

, (2)

where ? is there speed of working organ to the blow; ? is there speed of working organ after a blow; ? mass over of working organ is brought to the point of blow. Thus will the value of speed consist of, id est from ? rates of forward movement of digger and ? high speed of fluctuating motion of all oscillation excavation of working organ.

Is the vector of forward speed of digger directed for axes Oh, and vector of rate of a shake movement of working organ ? on wasp Oz upwards. Taking into account correlation, vector equation (2) will purchase a kind::

. (3)

Connection between speed of excavation of working organ after a blow and to the blow expressed through the coefficient of renewal at a blow [8] so that, id est through ? projection of speed of working organ

after a blow on a normal to the surface of wedge and ? projection of speed of working organ to the blow on a normal to the surface of wedge.

Виразивши of projection of speed of working organ after a blow and to the blow on a normal through the projections of these speeds on wasp of the cartesian system of coordinates of Oxyz will get equalization:

. (4)

Farther will write down vector equation (3) in projections on wasp of the cartesian system of coordinates of Oxyz, tacking equalization (4) to the got system of equalizations.

In the total have the system of 4th equalizations in relation to unknown,:

(5)

Deciding the system of equalizations (5) the method of Cramer, get the normal constituent of shock impulse :

(6)

Expression (6) describes functional dependence of normal constituent of shock impulse from the construction and kinematics parameters of oscillation excavation of working organ of beet-lifting machine.

The sign of "-" means in expression (6), that a shock impulse operates from the side of root crop on a working organ. A shock impulse that operates from the side of oscillation excavation of working organ on the root crop of beet saccharine has a positive sign and the same size.

However major description of shock process is a size of crushing power, but not shock impulse, as many indexes of фізико-механічних descriptions of beets saccharine are related exactly to efforts that operate on the root crop of beet from the side of oscillation excavation of working organ. It is known that crushing power for the short interval of time grows from a zero to the very large size, and then again falls to the zero. As marked in [8], her a maximal value will be approximately twice as much, than her mean value for the interval of time, id est:

, (7)

where ? maximal value of crushing power, is a shock impulse, is a mean value of crushing power, is duration of blow. Taking into account right parts of the first 3th equalizations of the system (5) and expression (7), able to write down the value of projections of force accordingly on wasp Oh, Oy and Oz ::

(8)

where a value is determined according to the expression (6) taken with a positive sign. Duration of blow is certain in [13] and a p. equals

Farther will consider the terms of unbreaking of root crop of beet during his shock co-operation from digging up by a working organ. If to examine the root crop as cantilever beam envisaged in soil, then under the action of moment from horizontal crushing power the root crop of beet tests deformation of bend. Therefore for exceeding of legitimate values of the mentioned moment a root crop can break. It, as marked higher, more credible than all, when soil, that surrounds the root crop of beet, dry and hard. If soil moist and soft, then more credible is inclination of root crop on a certain corner to horizon under the action of horizontal effort. If a blow takes place in a point that is contained in the distance from the conditional point of fixing (rice. 1), then a moment of horizontal constituent of crushing power is in relation to this point, taking into account, that, will equal::

. (9)

The condition of unbreaking of root crop of beet will be:

, (10)

where ? possible for the body of root crop bending moment there is not his breaking at that; it is a supporting moment of unloosening soil, there is the envisaged root crop of beet in that. Farther taking into account the condition of unbreaking of root crop (10) during the shock co-operating of excavation of working organ with the root crop of beet will define a limit on speed of working organ. Will enter such denotations:

(11)

(12)

After a substitution with the use of expressions (11) and (12) and transformation is found analytical expression that binds the rate of forward movement of oscillation excavation of working organ to the condition (10) of unbreaking of root crops of beets saccharine :

. (13)

Thus, as see from expression (13), a limit is found on the rate of movement of oscillation excavation of working organ taking into account his construction parameters and mass, and also durability of root crop and coefficient of renewal at a blow.

From the got expressions it is possible finally to define at the set amplitude necessary колову frequency and frequency of vibrations of excavation of working organ in hertzs on condition of unbreaking of root crop of beet saccharine :

(14)

Thus a possible bending moment is determined through is a diameter of root crop, is a corner of конусності of root crop of beet saccharine, - depth of motion of excavation of working organ in soil and is temporal resistance of bend of root crop at the dynamic loading.

On the base of the worked out theory of shock co-operation of oscillation excavation of working organ with the root crop of beet by means of PEC with the use of the program made in the environment of MathCAD the wide spectrum of possible frequencies of vibrations of working organ is certain on condition of unbreaking of root crops at the different values of construction and kinematics parameters of oscillation excavation of working organ.

A calculation on PEC is conducted at such preset parameter [13, 14]: = 15?; = 52?; = 0,45; = 45?; = 0,05 m; = 0,72; = 0,1 m; = 15?; Step; = 1,5 kg are for the 3th values of depth of motion in soil of oscillation excavation of working organ, namely = a 0,08 m; 0,10 m; 0,12 м. After the second expression (14) is expected possible frequency of vibrations of excavation of working organ as function from speed of him forward motion and amplitude of vibrations, id est . Thus the rate of forward movement of oscillation digger changes within the limits of a 1,4-2,2 m/of c, amplitude of his vibrations in a longitudinally-vertical plane - within the limits of 0,008-0,024 м. .

Results over of carried out on PEC of numerical calculations are brought in a table.

A depth of motion is in soil of working organ, m of нтервал change of frequency of vibrations of working organ, Hertzsц

As evidently from data of table, range of frequencies of vibrations = 0,243-3,89 Hertzs provides unbreaking of root crops of beets on the depth of motion of excavation of working organ a 0,12 m and less than, range of frequencies of vibrations = 4,01-15,17 Hertzs provides unbreaking of root crops on the depth of motion of working organ a 0,10 m and less than, and range of frequencies of vibrations = 9,97-33,08 Hertzs - on the depth of motion of excavation of working organ a 0,08 m and less than.

Thus, in theory it is possible to expect the value of frequencies of vibrations of oscillation excavation of working organ on condition of unbreaking of root crops of beets saccharine for enough wide spectrum of kinematics his office hours. On results calculations on personal electronic computer (PEC) ПЕОМ the chart of function and contour chart are built for the erected mass of oscillation digging up working organ = 1,5 kg and depths of his motion in soil =a 0,10 m (rice. 2).

а)

б)

Rice. 2. Surface (а) and contour chart (б) of values of possible frequency of vibrations of oscillation excavation of working organ, Hertzs on condition of unbreaking of root crops at their shock co-operation (depth of motion in soil of working organ = a 0,10 m; the erected mass of working organ = is 1,5 kg)

Conclusions

The equivalent chart of oscillation excavation of root crop of beet saccharine is worked out on the basis of consideration of shock co-operation of body of root crop with a ploughshare, when the delight of root crop takes place asymmetric, id est their contact comes true only in one point, taking into account all forces that arise up during such contact. Worked out an equation of shock co-operation of oscillation excavation of working organ with the body of root crop of the beet saccharine, envisaged in soil.

On the basis of equalization of shock co-operation a shock impulse and maximal crushing power are certain, that arise up at the mentioned co-operation.

On condition of unbreaking of root crops expression is got for determination of possible frequency of vibrations of oscillation excavation of working organ taking into account his construction parameters and forward rate of movement of beet-lifting machine.

A numerical decision on PEC of the got analytical dependences gave an opportunity to define possible frequencies of vibrations of oscillation excavation of working organ. As calculations showed, with the increase of amplitude of vibrations and rate of forward movement of working organ possible frequency of vibrations diminishes sharply..

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