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# JUSTIFICATION OF AUGER CLOD-CRUSHER OF THE POTATO HARVESTER

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**Abstract**

The reasons for the low degree of mechanization of potato harvesting are analyzed and it is proposed to equip the potato harvester machine with a passive auger clod-crusher. It will make possible to loosen the surface layer of the field with ridges, to grind plant residues and tubers, moving them with the loosened soil to the inter-field space, excluding their access to the potato harvester. The application of a clod-crusher will contribute to the full separation of the tuberous soil mass. A number of structural and technological parameters of auger clod-crusher were determined.

***Keywords***: potato harvester, clod-crusher, drum, knife, tuber, conical auger.

**Introduction**

With the constantly increasing volumes of potato cultivation, the degree of mechanization of potato harvesting is becoming increasingly important [1]. In the soil and climatic conditions of Armenia and Artsakh, the short agrotechnical terms of potato harvesting make this problem even more urgent.

The research has shown that the low level of mechanization of potato harvesting is due to the high roughness of the soil, due to which the process of separation of the the potato-soil mixture is incomplete [2], which does not allow to switch to the combine harvesting method. It turns out that the solution of the problem of mechanization in our conditions leads to the improvement of the separation process at the initial stage of harvesting/during the transition of the potato-soil mixture from the tuber-bearing bed to the potato harvester.

Many studies have been carried out in the world in order to improve the separation of tuberous soil mass and various solutions have been proposed, namely:

- before entering the potato harvester, loosen the rough surface of the field with ridge, grind plant residues and tubers, limit the entry of excess soil into the potato harvester, harvest in optimal humidity conditions [2],
- to model the technological processes [3],
- apply additional labor organs for crushing hard soil [4],
- organize double separation [5],
- to improve the design of the separating organs, to adjust the design and technological parameters of the potato harvesters [5,6,7],
- apply combined labor organs [6],
- at the basis of the separation process, use the difference in the contact properties of the soil and tubers with the working organs of the separators [8].

**Conflict Setting**

The task is to ensure the crushing of potato tubers, the grinding of the surface layer of the field with ridges and the transfer of crushed tubers to the interplant space.

**Research Results**

To solve the problem, it was proposed to equip the potato harvester with an auger crusher, which is installed in the front of the machine and operates due to the rotational movement resulting from sticking to the ground (Fig. 1).

The axis of the crusher is connected by levers with a potato harvester, which is driven by a tractor. During the movement of the aggregate, the moving rollers, which are located in the interplant space, with the help of the ground grippers attached to them, get a rotary motion, which is transmitted to the contour of the field with ridges / inclined platforms / rotating conical augers are rigidly connected to the roller, and from it to the knife drum. The drum sits on the field with ridges and, with the help of knives attached to it, loosens the coarse soil of the central, relatively flat area of the potato tuber bed, simultaneously cutting and shredding the potato tubers in the direction of the process.

Conical augers, which are located in the sloping areas of the field with ridges, loosen the surface soil of that area and move it to the the interplant area. Due to the external pointed part of the augers, the potato tubers on the sloping sections of the field with ridges are also cut off and moved to the interplant space with the surface soil layer. As a result, the amount of coarse soil and tubers entering the potato harvester is reduced, as a result of which the potato separation process is improved.

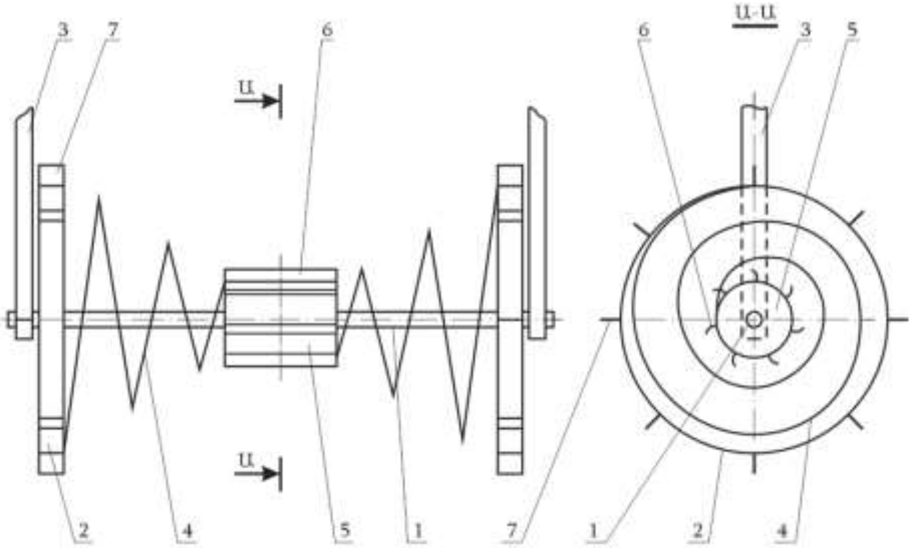


**Fig. 1 The scheme of the conical augers of potato harvester.**
**1 - axle, 2 - driving roller, 3 - lever, 4 - conical auger,**
**5 - knife drum, 6 - knife, 7 – soil sticking part**

To determine the design and technological parameters of the proposed crusher, consider the crusher as a rigid unity of three aggregates that perform different functions: drive rollers with soil sticking parts, two conical augers and a knife drum.

The crusher is such that it copies, or in other words "hugs" the field with ridges. Therefore, some parameters of the crusher were selected based on the geometric shape of the field with ridges, the location of potato tubers in the filed with ridges, the interplant space, and the structure of the aggregate. Thus, they were specifically clarified.

- The width of the knife drum, /equivalent to the width of the upper part of the field with ridges /, which is approximately: $B_d$=20 cm:
- The diameters of the knife drum and roller, respectively have made $D_d$= 13cm and $D_r$=30mc. These dimensions were obtained based on the outline of the field with ridges, taking into account the limitations of its overall dimensions, depending on the operating conditions of the clod- crusher.
- The drum`s knife`s height $h_{k=}$2cm. It was chosen based on the condition of not damaging with knives the tuber bed at the top of the field with ridges.
- The length of the conical augers is $D_d$=13cm. It is equivalent to the width of the sloping spaces of the field with ridges.
- The degree of sticking of the rollers of conical augers into the soil in the sloping parts of the field with ridges is $h_a$=3cm. It has been determined based on the condition of the tubers not being damaged in these parts of the field with ridges.
- The degree of sticking of the conical augers` rollers into the soil in the sloping parts of the field with ridges is $h_a$=3cm. It has been determined based on the condition of the tubers in order not to damage the tubes in these parts of the field with ridges.

We haven`t referred to the size, shape and number of the soil-sticking parts of the movable rollers of the clod-crusher, bearing in mind that similar studies regarding the movement of mechanisms as a result of sticking to the soil have been carried out and applied in practice in the past.

In particular, in [9], which also refers to the movement of a crusher with the soil-sticking parts were determined the parameters , which we took as a basis.

Let's determine the parameters of the conical auger. The edge coils of the auger are rigidly connected to the knife drum on one side and to the drive roller on the other. Therefore, when calculating their diameters, it is necessary to take into account the fact that they are attached to the machine, as well as the degree of their depth into the soil on the sloping side of the field is $h_a$.

Therefore, the diameter of the big coil of the auger will be

$$D_{big\ coil} = D_c + 2h_a = 36cm. \quad (1)$$

The diameter of the small coil of the auger will be

$$D_{small\ coil} = D_d + 2h_k = 17cm. \quad (2)$$

The number of rotation of the cylinder depends on the parallel speed of the aggregate and can be determined from the following expression (we assumed that the cylinder slip is zero):

$$V_m t = \pi D_c\ n_{c}, \quad (3)$$

where $V_m$ is the working speed of the potato harvester which is widely used in Armenia and Artsakh, which is given about 3km/h or 0.83m/s for the KTN-2B potato harvester t is the calculation time we accept.

Therefore, the number of rotation of the roller will be:

$$n_r = V_m t / \pi D_r = 53\ \mathrm{r/m}: \quad (4)$$

The knife drum is rigidly connected to the auger, which is rigidly connected to the drive roller. Therefore, the rotations of the auger $n_a$, knife drum $n_d$ and movable roller $n_r$ are the same.

$$n_a = n_d = n_r = 53\ \mathrm{r/m}$$

The motion of the conical auger was determined using the usual constant diameter auger`s parametrization theory.

The peculiarity in this case is that the diameters of the neighboring coils are gradually increasing alongside with the direction of the soil transportation.

When determining the parameters of the conical auger, the diameter of the smallest coil is taken as the basis, based on the fact that all the coils of the conical auger are fed with the soil layer of the same width, so the coil with the smallest diameter will be the most loaded.

It is known that the following connection exists between the motion of the auger S and the diameter $D_a$.

$S=kD_a$ ,where k is coefficient determined experimentally. K=0,8- 1,0, in that case the auger turns out with perfect constructive parameters [10].

Let's take k=0.8.

In our case $D_a = D_{small\ coil} = 17$ cm.

Therefore, the motion of the auger will be S = 13,6 cm. Resulting from the combination of motion and length of the auger /$L_a$ = 26cm/ it is clear that between big and small coils of the conical auger we may have only one coil which diameter will be

$$D_{medium\ coil} = (D_{big\ coil} + D_{small\ coil})/2=26,5 \tag{5}$$

According to the basis theory of the parameters of the auger, the number of the auger motion must satisfy the following condition [10]. $n_a \leq n_{max}$, where $n_{max}$ is the maximum motion number of the auger, for which calculation is applied the following formula:

$$n_{max} = A/\sqrt{D_a} \tag{6}$$

Where A is coefficient depending on transported material, which in the case of being a soil is in the range values 22÷45. Therefore, we will get:

$$n_{max} = 53 \div 108_{m/min}$$

Therefore, $n_a \leq n_{max}$ condition satisfies

The conical auger should satisfy another condition too $\beta \leq \varphi$, where $\beta$ is the angle of the auger conicity, $\varphi$ is the relation angle between the auger and the soil surface of the filed with ridges. $\varphi = 22 - 45^0$ [10]:

Let`s determine the angle of conicity of the auger using pic.1

$$tg\,\beta = (D_{coil\ big}-D_{coil\ small})/2/L_a= 0,365, \tag{7}$$

and $\beta = 17^0$c. Therefore, satisfies $\beta \leq \varphi$ condition too.

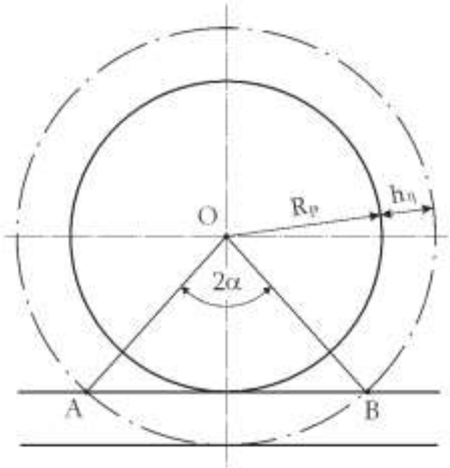


**Fig. 2 The scheme for determining the number of drum knives**

Now let's refer to the knife drum of the clod-crusher. From a technological point of view it has been already justified that the width of the drum is 20 cm, the diameter is 13 cm, the height of the knives are 2 cm. The number of the motion of the drum was also determined – 53m/min. It remains to calculate the necessary number of knives.

The number of the knives has been determined on the condition that there is not uncultivated area alongside with the motion direction of the drum.This condition will be satisfied in that case when one knife at the time of coming out from the soil ( point B), the following knife will enter the soil( point A ). From pic.2 we have

$$\cos\alpha = \frac{R_d}{(R_d + h_k)} = 0{,}87, \qquad (8)$$

Therefore, $\alpha = 29^0$

The angle formed by two consecutive knives will be $2\alpha = 58^0$.

Therefore, the minimum number of the knives will be $Z = 360/58 = 6{,}2$.

Let`s accept the necessary number of knives $Z = 7$

During the work the drum of the clod-crusher does a complicated rotative movement around the axis $\omega R_d$ with circumferential speed ( $\omega$ is angular velocity of the drum) and is moving in tandem with speed $V_m$.

This process is characterized by a kinematic indicator $(\lambda)$.

$$\lambda = \frac{\omega(Rd + \mathrm{hd})}{vm} \qquad (9)$$

The angular velocity of the drum was determined by the following formula [10].

$$\omega = \pi nd/30 = 5{,}54. \qquad (10)$$

Therefore, the kinematic indicator will be $\lambda = 0{,}56$:

This value of the kinematic index is typical for machines with passive action.The proposed clod- crusher is also ranked among them.

In general, for a more efficient operation of the knife drum, it is necessary to ensure the condition $\omega R_d > V_m$, or $\lambda > 1$, in which case the trajectory of the absolute motion of the knife will be cycloid. This can be achieved by making the clod-crusher active. In the case of a passive clod- crusher, it will be necessary to increase the number of knives on the drum to improve the crushing quality. Adjustment of this and other parameters of the proposed clod-crusher will be done in the near future, after analyzing the results of laboratory and field experiments.

**Conclusion**

The researches have shown that in the soil and climate conditions of Armenia and Artsakh, the separating organs of the potato harvesters used during potato harvesting do not perform sufficient separation of the tuber soil mass, as a result of which the degree of mechanization of potato harvesting is low.

To increase the separation efficiency of potato harvesters, one more separating unit should be added to the design of potato harvester. In other words, the tuberous soil mass is separated in two stages: the first before entering the potato harvester, the second - into the potato harvester.

For the first stage, it was suggested a passive action cone crusher moving with the help of sticking , which will be located between the tractor and the potato harvester, and will be connected to the potato harvester with articulated levers. Due to this, before the potato harvester machine`s ploughs are drawn into the upper part of the field with ridges, the latter`s surface with a soil layer 2-3 cm thick including hard soil, is crushed and taken out into the inter-field space. At the same time, a significant part of the potato tuber is crushed and partially transferred to the inter-plant space. As a result, the amount of soil, hard soil and tuber in the tuber-soil mass entering the potato harvester will decrease, and the load will also be significantly reduced on the separation unit of the potato harvester.

This will contribute to the complete separation of the tuber-soil mass in the potato harvester and will create an opportunity to significantly reduce manual work during harvesting and even reach the combine harvesting option.

## References


1. Nefedov B.A. and others (2016) New Technical Solutions for Separating Organs of Potato Harvesters //Polythematic Online Scientific Journal of Kuban State Agrarian University Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета. https://cyberleninka.ru/article/n/novye-tehnicheskie-resheniya-separiruyuschih-organov-kartofeleuborochnyh-mashin
2. Pisarik A. (2011) Potato Harvesting Technology in Difficult Field Conditions Using Innovative Solutions in the Design and Maintenance of Harvesters //Abstract of the dissertation for the degree of Doctor of Technical Sciences, Specialty 05.20.01 - Technologies and Means of Mechanization of Agriculture, Ryazan. https://infolisting.ru/category/1glf7lj524g7ni_notes.shtml
3. Abbasov G.I. (2019) Research of Technological Process of Harvesting and Post-harvest Processing of Potatoes //Agrarian science, (6).- p. 33-35. https://doi.org/10.32634/0869-8155-2019-329-6-33-35.%20 https://www.elibrary.ru/item.asp?id=39182043
4. Yakutin N.N., Kascheev I.I. (2014) Grounding the Parameters of the Means Intensifying Separation of Potato Harvesters' Main Elevator //Modern problems of science and education – № 6. https://science-education.ru/ru/article/view?id=16030
5. Kushchev I.E. (1999) Development of a Branching Technology for Harvesting Potatoes with the Justification of the Parameters and Modes of Operation of the Separating Devices //Abstract dis. According to the Higher Attestation Commission of the Russian Federation 05.20.01, Doctor of Technical Sciences.- 466 p. https://www.dissercat.com/content/razrabotka-razvetvlyayushcheisya-tekhnologii-uborki-kartofelya-s-obosnovaniem-parametrov-i-r
6. Suzdaleva G.F. (2005) Technology of Separation of Soil-potato Heap with Substantiation of Design and Regime Parameters of the Elevator with Combined Rods and Intensifier. Abstract dis. according to the Higher Attestation Commission of the Russian Federation 05.20.01, Candidate of Technical Sciences. 169 p. https://www.dissercat.com/content/tekhnologiya-separatsii-pochvenno-kartofelnogo-vorokha-s-obosnovaniem-konstruktivno-rezhimny

7. Byshov N.V., YakuninY.V., Yakutin N.N. (2013) Improving the Separation of a Tuber-Containing Heap at Various Stages of Harvesting Technology //Vestnik of the Ryazan State Agrotechnological University after P.A. Kostycheva.- p.49-51.
   Вестник Рязанского государственного агротехнологического университета им. П.А.
   https://cyberleninka.ru/article/n/sovershenstvovanie-separatsii-klubnesoderzhaschego-voroha-na-razlichnyh-etapah-tehnologii-ubork
8. Zubkov V.E. (2009) Technological Basis for the Separation of Potato Tubers and Soil Clods by a Friction Separating Device of a New Type //Niva of the Volga region, N2 (11).- 5p.
   https://cyberleninka.ru/article/n/tehnologicheskie-osnovy-separatsii-klubney-kartofelya-i-pochvennyh-komkov-friktsionnym-separiruyuschim-ustroystvom-novogo-tipa
9. Taverdyan A.P., Hayrapetyan H.H. (2019) Theory and Calculation of Geometric and Kinematic Parameters of the Rotor Clod Crusher Drive in the Potato-Digger. 4(68).- p. 16-22.
   https://anau.am/teghekagir/
10. Grigoryan Sh.M., Khachatryan A.Ts., Minasyan R.S. (1998) Geotechnical mechanics //Yerevan HGA.- 320 p.
   extension://efaidnbmnnnibpcajpcglclefindmkaj/https://library.anau.am/images/stories/grqer/Gyughatntesutyun/erkragortutun.pdf

## References

1. Нефедов Б.А. и др. (2016) Новые технические решения сепарирующих органов картофелеуборочных машин**.** Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета. 2016г. https://cyberleninka.ru/article/n/novye-tehnicheskie-resheniya-separiruyuschih-organov-kartofeleuborochnyh-mashin
2. Писарик А. (2011) Технология уборки картофеля в сложных полевых условиях с применением инновационных решений в конструкции и обслуживании уборочных машин //Автореферат диссертации на соискание учёной степени доктора технических наук, Специальность 05.20.01 – Технологии и средства механизации сельского хозяйства, Рязань.
   https://infolisting.ru/category/1glf7lj524g7ni_notes.shtml
3. Аббасов Г.И. (2019) Исследование технологического процесса уборки и послеуборочной обработки картофеля. Аграрная наука, (6): с. 33-35. https://www.elibrary.ru/item.asp?id=39182043
4. Якутин Н.Н., Кащеев И.И. (2014) Обоснование параметров средства интенсификации сепарации основного элеватора картофелуборочныхмашин //Современные проблемы науки и образования, № 6.
   URL: https://science-education.ru/ru/article/view?id=16030
5. Кущев И.Е. (1999) Разработка разветвляющейся технологии уборки картофеля с обоснованием параметров и режимов работы сепарирующих устройств. Автореферат дис. по ВАК РФ 05.20.01, доктор технических наук.- 466 с.
   https://www.dissercat.com/content/razrabotka-razvetvlyayushcheisya-tekhnologii-uborki-kartofelya-s-obosnovaniem-parametrov-i-r
6. Суздалева Г.Ф. (2005) Технология сепарации почвенно-картофельного вороха с обоснованием конструктивно-режимных параметров элеватора с комбинированными

прутками и интенсификатором. Автореферат дис. по ВАК РФ 05.20.01, кандидат технических наук.- 169с. https://www.dissercat.com/content/tekhnologiya-separatsii-pochvenno-kartofelnogo-vorokha-s-obosnovaniem-konstruktivno-rezhimny

7. Бышов Н.В., Якунин Ю.В., Якутин Н.Н. (2013) Совершенствование сепарации клубнесодержащего вороха на различных этапах технологии уборки //Вестник Рязанского государственного агротехнологического университета им. П.А. Костычева.- с. 49-51 https://cyberleninka.ru/article/n/sovershenstvovanie-separatsii-klubnesoderzhaschego-voroha-na-razlichnyh-etapah-tehnologii-ubork
8. Зубков В.Е. (2009) Технологические основы сепарации клубней картофеля и почвенных комков фрикционным сепарирующим устройством нового типа. Нива Поволжья, N2 (11).- 5 с. https://cyberleninka.ru/article/n/tehnologicheskie-osnovy-separatsii-klubney-kartofelya-i-pochvennyh-komkov-friktsionnym-separiruyuschim-ustroystvom-novogo-tipa
9. Թարվերդյան Ա.Պ., Հայրապետյան Հ.Հ. (2019) Կարտոֆիլահանի ռոտորային կոշտամանրիչի շարժահաղորդակային մեխանիզմի կինեմատիկական և դինամիկական հետազոտություն. 4(68).- էջ 16-22: https://anau.am/teghekagir/
10. Գրիգորյան Շ.Մ., Խաչատրյան Ա.Ց., Մինասյան Ռ.Ս. (1998) Երկրագործական մեխանիկա, Երևան ՀԳԱ.- 320 էջ: extension://efaidnbmnnnibpcajpcglclefindmkaj/https://library.anau.am/images/stories/grqer/Gyughatntesutyun/erkragortutun.pdf

## ԿԱՐՏՈՖԻԼԱՀԱՆԻ ՇՆԵԿԱՅԻՆ ԿՈՇՏԱՋԱՐԴԻՉԻ ՊԱՐԱՄԵՏՐԵՐԻ ՀԻՄՆԱՎՈՐՈՒՄԸ

**Ա.Մ. Եսոյան** [1], **Գ.Մ. Միքայելյան** [2,3], **Ա.Ա. Եսոյան**[4], **Ս.Ա. Ադամյան** [2]
[1]*Հայաստանի ազգային ագրարային համալսարան*
[2]*Շուշիի տեխնոլոգիական համալսարան*
[3]*Ստեփանակերտի Գրիգոր Նարեկացի համալսարան*
[4]*Երևանի պետական համալսարան*

Վերլուծվել է կարտոֆիլի բերքահավաքի մեքենայացման ցածր աստիճանի պատճառները և առաջարկվել է կարտոֆիլահան մեքենան համալրել պասիվ գործողության շնեկավոր կոշտաջարդիչով: Այն հնարավորություն կտա մարգաթմբի մակերեսային շերտը փխրեցնել, բուսածածկույթը և կարտոֆիլի փրերը մանրացնել և փխրեցված հողի հետ տեղափոխել միջմարգային տարածք, բացառելով դրանց մուտքը կարտոֆիլահան մեքենա: Կոշտաջարդիրչի կիրառումը կնպաստի պալարահողային զանգվածի լիարժեք զատմանը: Որոշվել են շնեկավոր կոշտաջարդիչի մի շարք կառուցվածքային և տեխնոլոգիական պարամետրեր:

***Բանալի բառեր.*** կարտոֆիլահան, կոշտաջարդիչ, թմբուկ, դանակ, պալար, կոնական շնեկ:

# ОБОСНАВАНИЕ ПАРАМЕТРОВ ВИНТОВОЙ КОМКОДРОБИЛКИ КАРТОФЕЛЕКОПАТЕЛЯ

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Проанализированы причины низкой степени механизации уборки картофеля и предложено комплектировать картофелекопатель винтовой комкодробилкой пассивного действия. Это позволит разрыхлять поверхностный слой грядки, измельчать растительность и картофельную ботву, переместить их с разрыхленной почвой в межрядовое пространство, исключив их доступ к картофелекопателю. Внедрение комкодробилки будет способствовать полному отделению клубневой массы от почвы. Определен ряд конструктивных и технологических параметров винтовой комкодробилки.

***Ключевые слова:*** картофелекопатель, комкодробилка, барабан, нож, клубень, конический шнек.

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