MACHINES AND TOOLS MEKHANIZATSII

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EFFECT OF MECHANICAL LOSSES ZERNAZA THRESHING-SEPARATING DEVICE KOMBAYNIVNA THEIR PERFORMANCE

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The theoretical dependence of the performance of mechanical harvesters losses arising threshing-separating device. Determined characteristic dependence on bandwidth HCC term harvest rate through the shedding of grain and threshold value losses on SMEs.

Performance, capacity, shedding grain threshing-separating device.

Problem. It is known that the performance of combine harvesters (HCC) is affected by objective and subjective factors and factors. Summarizing the structural and technological characteristics of potential productivity HCC serves downloads (IPU) through capacity index (kg / s). In recent years, manufacturers of HCC in the technical documentation no longer provide constructive, technically, technologically reliable indicators of capacity and show numerical values of pure grain milling.

In the calculation formulas of numerical values of operating speed and performance HCC is an indicator of bandwidth. In the absence of rate bandwidth combines new models use the formula to calculate the predicted performance combine purchased is not possible. In addition to the structural and lack of information is hidden flaw of modern combine harvesters equipped with electronic and computer systems for ongoing monitoring and recording the relative values of mechanical losses of grain by IPS.

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Analysis of recent research. Applied research [2, 3] was found when using on-board current control devices for mechanical losses SMEs that are mounted in the cab as icons or graphics dependence on the dashboard for adjustment to the required performance, the relative value of max engine load reaches 67% the nominal value. The procedure for adjusting combine into a new area harvested crops involves the following sequence: it is necessary to estimate the probable yield of culture, which is expected to gather in zahintsi pass 80-100 meters and adjust recorder losses to the required sensitivity. When using relative values of mechanical losses for adjusting the sensitivity of the possible (subjective, visually estimated operator productivity) that mistakes are inevitable.

In addition to possible errors subjective operators (combine) often agricultural technologies, agricultural experts who monitor the operation of harvesting in the field without knowing the actual load of the engine, using subjective methods to control the mechanical losses into account grain on the earth and straw, and often limit the working speed clearly overestimating the significance and importance of mechanical losses for SMEs and underestimating future losses from shattering through delaying harvest. Harvest is not lossless.

The loss must be calculated and forecast before the harvest, for objective calculation of rates harvesting in ahrostroky than counting losses from loss, shedding, quality losses.

The capacity is determined by the number of threshing the grain mass passing through the thresher per unit time (kg / s), with a ratio of grain to straw by weight of 1: 1.5 for normal harvesting when grain losses for SMEs does not exceed 1.5% gross harvest of grain harvested from field areas. Bandwidth thresher determined by the empirical formula [1]:

$$q = \frac{BV_pU}{360}. \quad (1)$$

For combines Don-1500, Don-1500B, Barrier-9.1 at an operating speed zahintsi $V_p = 3$ km / h Reaper width B = 6 m, yields U = 108 kg / ha, the capacity will be 5.4, although manufacturers claimed $q = 9$ kg / s.

For the first time the influence of feeding meat supply in SMEs combines the relative importance of mechanical threshing instrument showed losses for the company "Klaas" to combine «Dominator 108 SL Maxi» graphic above-mentioned formula [5]. Thresher in given conditions is able to process a lot of meat on the submission of more than 12 kg / s, but the grain losses exceed 2.5%. Therefore, the optimal capacity of the combine is considered q = 11,4 kg / s at which the mechanical losses do not exceed 1.5% of the normative values of gross harvest harvested crops.

With graphical dependence (Fig. 1), it follows that the engine load yea weight 9.4 kg / s mechanical losses do not exceed 0.5%, while load increased from 9 to 11.4 kg / s losses increased sharply to 1.5%.

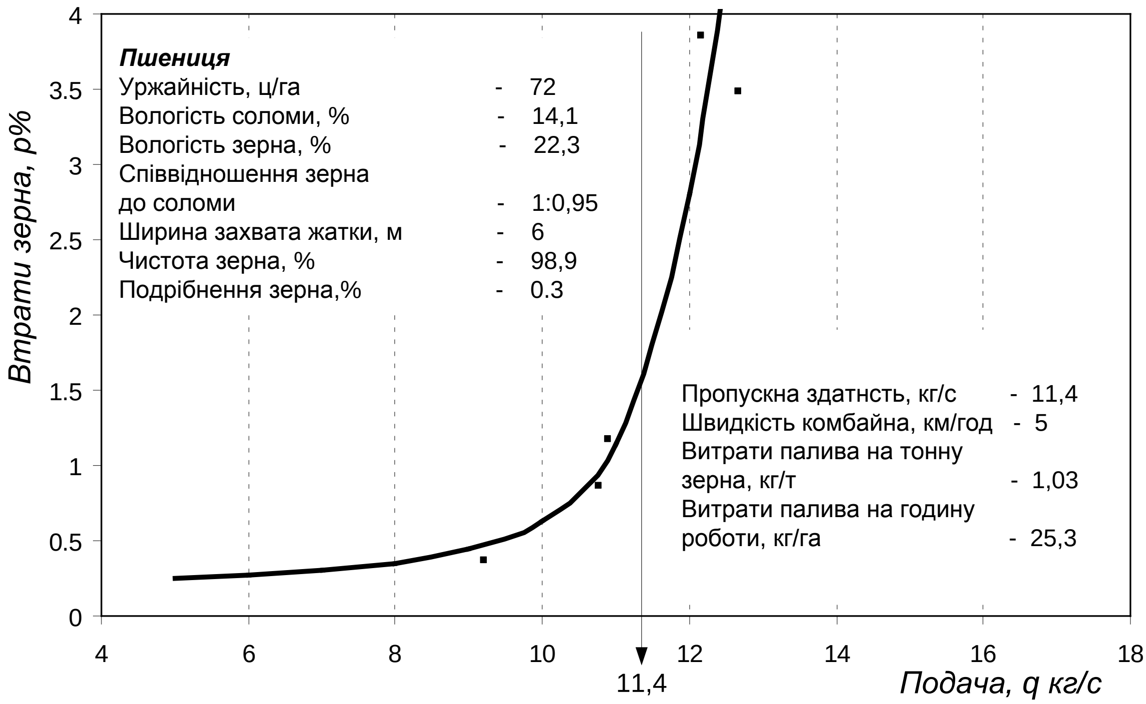

Fig. 1. Dependence of grain losses on a combine threshing instrument «Dominator 108 SL Maxi» of filing.

This tracker performance of mechanical losses found no theoretical justification. The authors present a graphical dependencies result in parallel tracker increasing loss of engine power for threshing hlibostoyu capacity of 1 kg / s and at its crushing spent capacity to combine movement.

Results. With shown in Fig. 1 unknown characteristics by which factor increases throughput performance and especially if the ratio of grain to straw 1: 0,95 = const, Reaper width = const, combine speed Vp = 5 km / h = const, fuel consumption = const. Corporation AHKO informational brochures to induce firm combines the tracker performance, depending on the relative values of losses for threshing instrument (Fig. 2). In comments to Fig. 2 provides the following text. "What are grain losses? Can I keep picking up more speed? "Allowable losses depends on the current situation and the conditions in which the collection is. For example can be expected to change in the weather, which is forecast after one or two weeks will go rain. In this case, the collection will have to spend at a higher rate to collect more grain despite the fact that its losses will increase. "

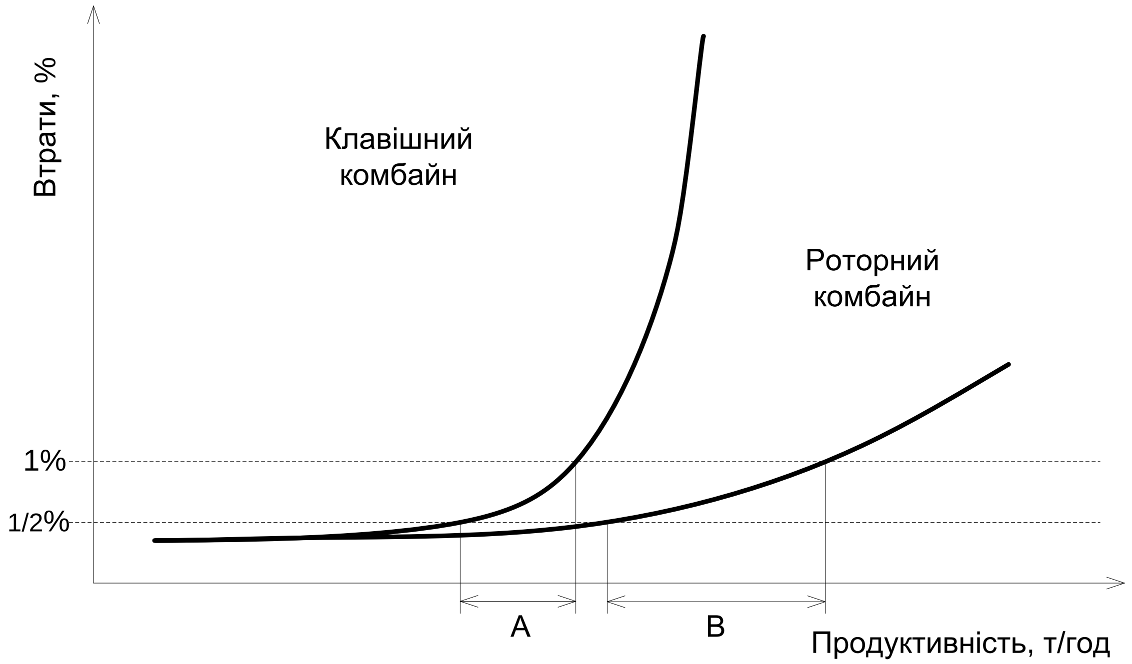

Fig. 2. Dependence of performance HCC Corporation AHKO of mechanical losses for IPS combines.

When harvesting combines traditional structural chart as we move closer to the limit bandwidth separating device mechanical losses increased sharply. As a result of increased losses from 0.5% to 1.0% corresponds to very small performance boost. Since the rotary combines separation is performed more efficiently, increase productivity will be higher.

For postulate VM Haryachkyna [1] natural and physical phenomena and processes have three stages:

- starting with a positive acceleration (for curved curve);
- average inertia (in a straight line or close to it);
- end with negative acceleration (in convex).

Overall schedule this process VM Haryachkin presented S-shaped integral curve (Fig. 3).

This fundamental postulate is important to evaluate the dynamics of any process, as it gives the coordinates development. To analyze the process VM Haryachkin consider the following expression:

$$\frac{dx}{dt} = a - x, \quad (2)$$

where dx - variable process parameters; dt - time variable; and - the boundary (limit) parameter x.

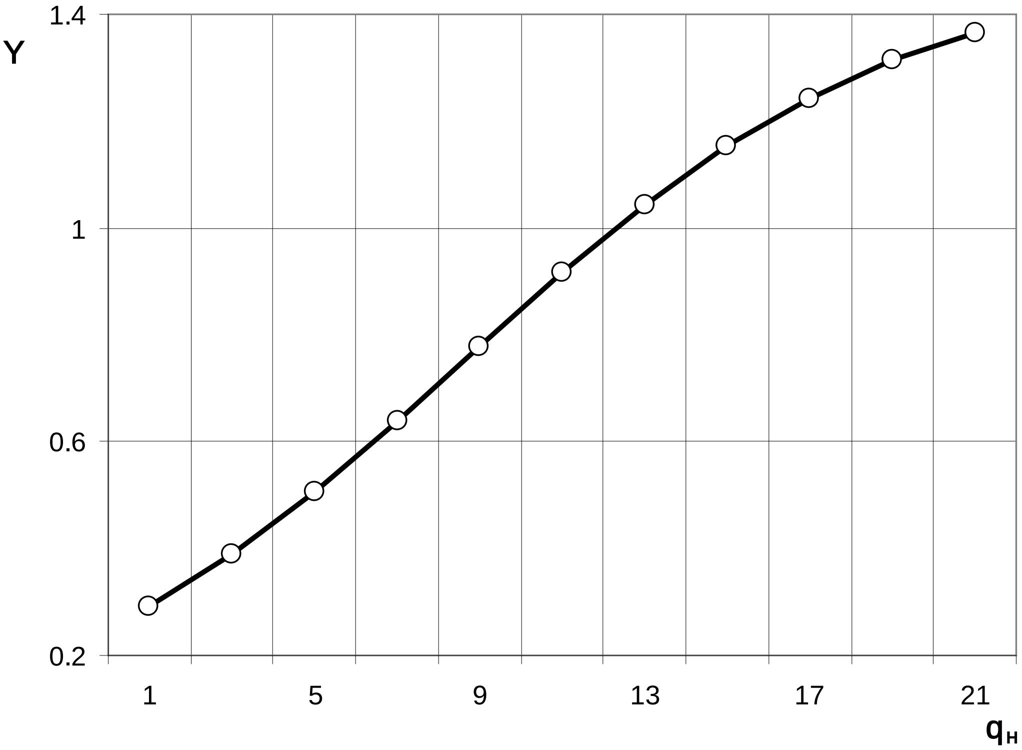

Fig. 3. Dependence throughput LC from mechanical damage.

Professor EM Zhalnin shown [2, 3] that the working characteristics of HCC can be used postulate Haryachkyna VM for differential equations with separate coefficients:

$$\frac{dy}{dg} = ky\left(y_{\text{гр.}} - y\right), \tag{3}$$

where y - current mechanical grain relative costs for SMEs HCC; k - coefficient of intensity of the process of growth of grain losses; yhr - marginal cost of grain; g - feed cereal thresher mass in kg / s.

To solve algebraic equations execute transformation:

$$\frac{dy}{ky\left(y_{\text{гр.}} - y\right)} = dg\ . \tag{4}$$

Integrate both sides of the equation:

$$\int dg = \int \frac{dy}{ky\left(y_{\text{гр.}} - y\right)}. \tag{5}$$

Consider a separate part of the equation:

$$\int \frac{dy}{ky\left(y_{\text{гр.}} - y\right)} = \frac{1}{k}\int \frac{dy}{y\left(y_{\text{гр.}} - y\right)}. \tag{6}$$

Decompose integrand into elementary fractions:

$$\frac{1}{y(y_{гр.}-y)}=\frac{\mathrm{A}}{\mathrm{y}}+\frac{B}{y(y_{гр.}-y)}=\frac{A(y_{гр.}-y)+By}{y(y_{гр.}-y)}. \quad (7)$$

Then equating the numerator, we find A and B by uncertain factors:

$$1=Ay_{гр.}-Ay+By. \quad (8)$$

Equating the coefficients of the same powers of ends

$$\int\frac{dy}{ky(y_{гр.}-y)}=\frac{1}{k}\left(\frac{\frac{1}{y_{гр.}}}{y}+\frac{\frac{1}{y_{гр.}}}{y_{гр.}-y}\right)dy=\frac{1}{ky_{гр.}}\int\left(\frac{1}{y}+\frac{1}{y_{гр.}-y}\right)dy= . \quad (9)$$

$$\frac{1}{ky_{гр.}}\left(\frac{1}{ky_{гр.}}y-\ln(y_{гр.}-y)\right)+C$$

Or in general will have the following equation:

$$g_{ш}=\frac{1}{ky_{гр.}}\left(\ln\frac{y}{y_{гр.}-y}+\ln\frac{1}{C}\right) \text{Where C - arbitrary const} \quad (10)$$

$$ky_{гр.}g_{ш}=\ln\frac{y}{C(y_{гр.}-y)} \text{Then} \quad (11)$$

$$\frac{y}{(y_{гр.}-y)}=C\exp(\mathrm{k}y_{гр.}y),$$

$$y(1+C\exp(ky_{гр.}\mathrm{g}))=y_{гр.}C\exp(ky_{гр.}\mathrm{g}),$$

$$y=\frac{y_{гр.}C\exp(ky_{гр.}\mathrm{g})}{1+C\exp(ky_{гр.}\mathrm{g})}=\frac{y_{гр.}}{1+C^{-1}(-ky_{гр.}\mathrm{g})},$$

$$y=\frac{y_{гр.}C\exp(ky_{гр.}\mathrm{g})}{C+\exp(ky_{гр.}\mathrm{g})}. \quad (12)$$

For the initial conditions y (0) = 0.1%, the constant C be C = 5. After some transformations we obtain equation 12:

$$y=\frac{y_{гр.}\exp(ky_{гр.}\mathrm{g})}{\exp(ky_{гр.}\mathrm{g})+C}. \quad (13)$$

Given the initial condition y (0) = 0.1% and taking $y_{гр.}=1{,}5$; k = 0,125, for a total equation, we have:

$$0.1=\frac{y_{гр.}}{1+C}\Rightarrow C=10y_{гр.}-1 \text{(Definition of constants).} \quad (14)$$

So the total equation will look like:

$$y=\frac{y_{гр.}\exp(ky_{гр.}\mathrm{g})}{\exp(ky_{гр.}\mathrm{g})+10y_{гр.}-1}. \quad (15)$$

The calculation of the equation hold for 15 values k (0.125, 0.25, 0.5, 0.75, 1.0), and the value of losses $y_{гр.}$ (1.5; 2.0; 2.5; 3.0; 3.5).

Graphic Depending productivity through bandwidth and value of grain losses are shown in Fig. 4.

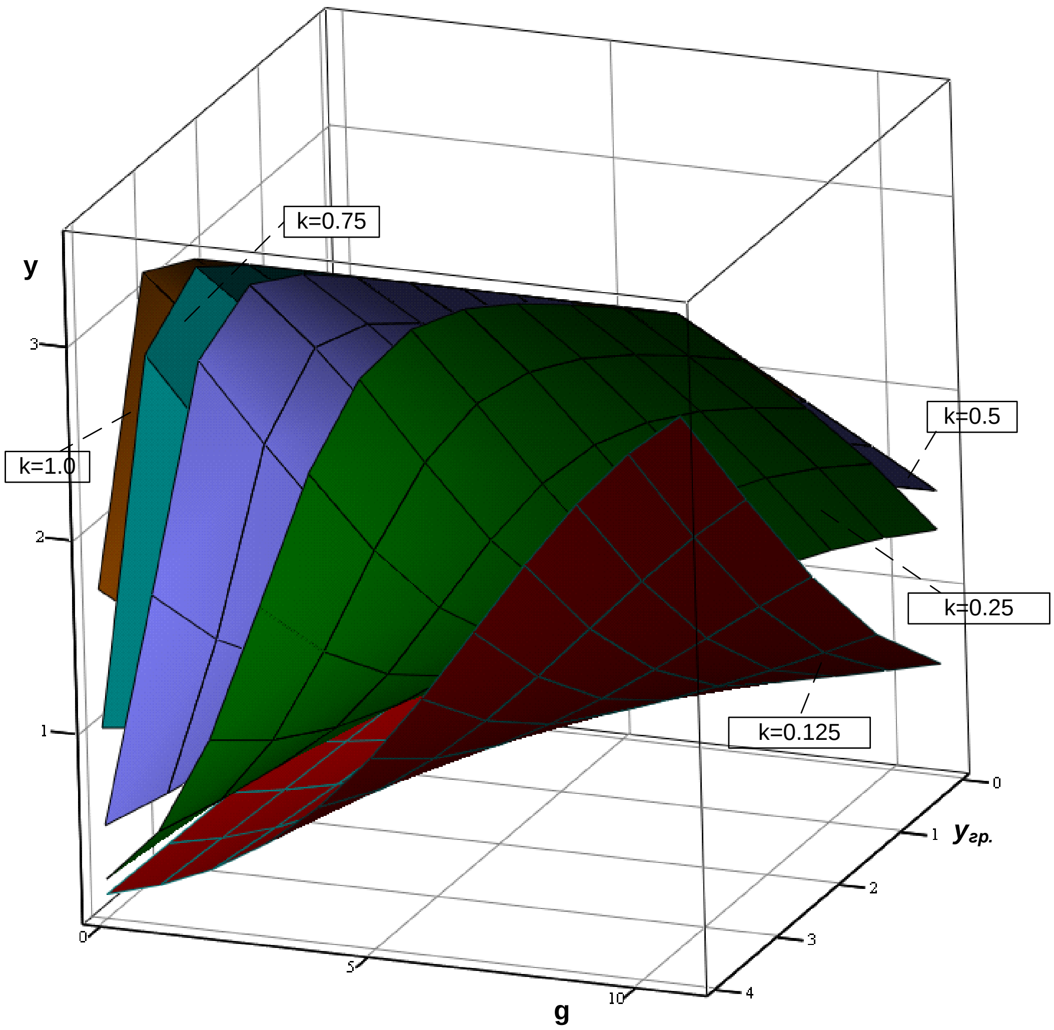

Fig. 4. Surface patterns of change mechanical losses on the degree of congestion through the thresher IPS throughput.

In all variants study patterns of change mechanical losses on the degree of congestion through the thresher capacity of SMEs serves threshold of significance for SMEs Grain Loss of gross harvest.

Upon reaching the limit value of mechanical losses in the cockpit display for the operator highlighted red signal and audio buzzer, which serves as a visual and audible limiting factor to reduce operating speed under load and thresher by reducing capacity (kg / s).

Graphic dependence shown in Fig. 4 do not support changing the pattern of mechanical losses depending on the threshing increasing load (kg / s) are shown in Fig. 1, Fig. 2.

Graphic dependence (Fig. 4) mechanical losses increase with increasing load grain threshers are more reminiscent of the S-curve, which provided Haryachkin (Fig. 3).

Find the inflection point for a function that tells us the load at which begins to slow down the rate of change y. Rewrite function as: $y = y_{гр.}\left(1 + C\exp\left(-ky_{гр.}g_п\right)\right)^{-1}$ Then

$$y' = y\frac{C\exp\left(-ky_{гр.}g_п\right)\cdot\left(ky_{гр.}\right)}{\left(1 + C\exp\left(-ky_{гр.}g_п\right)\right)^2} = Cky_{гр.}^{\ 2}\frac{\exp\left(-ky_{гр.}g_п\right)}{\left(1 + C\exp\left(-ky_{гр.}g_п\right)\right)^2};$$

$$y'' = Cky_{гр.}^{\ 2}\frac{\exp\left(-ky_{гр.}g_п\right)\cdot\left(-ky_{гр.}\right)\cdot\left(1 + C\exp\left(-ky_{гр.}g_п\right)\right)^2 - 2\left(1 + C\exp\left(-ky_{гр.}g_п\right)\right)\cdot}{\left(1 + C\exp\left(-ky_{гр.}g_п\right)\right)^4}$$

$$\frac{\cdot C\exp\left(-ky_{гр.}g_п\right)\left(-ky_{гр.}\right)\cdot\exp\left(-ky_{гр.}g_п\right)}{} =$$

$$= Ck^2y_{гр.}^{\ 3}\exp\left(-ky_{гр.}g_п\right)\frac{\left(1 + C\exp\left(-ky_{гр.}g_п\right)\right) - 2C\exp\left(-ky_{гр.}g_п\right)}{\left(1 + C\exp\left(-ky_{гр.}g_п\right)\right)^3} = \tag{17}$$

$$= Ck^2y_{гр.}^{\ 3}\exp\left(-ky_{гр.}g_п\right)\frac{1 - C\exp\left(-ky_{гр.}g_п\right)}{\left(1 + C\exp\left(-ky_{гр.}g_п\right)\right)^3}$$

$y'' = 0$ Hence we have:

$$1 - C\exp\left(-ky_{гр.}g_п\right) = 0 \text{ or } \exp\left(ky_{гр.}g_п\right) = C, \tag{18}$$

$$ky_{гр.}g_п = \ln(C) \text{ And hence } g_n = \frac{\ln(C)}{ky_{гр.}} \text{ - A point of inflection.} \tag{19}$$

$$\text{If } y(0) = 0{,}1\% \text{ Then } g_n = \frac{\ln\left(10y_{гр.} - 1\right)}{ky_{гр.}}. \tag{20}$$

Taking into account the same coefficient of grain shattering loss and threshold value for SMEs has been constructed surface and graphics bandwidth distribution (Fig. 5, Fig. 6).

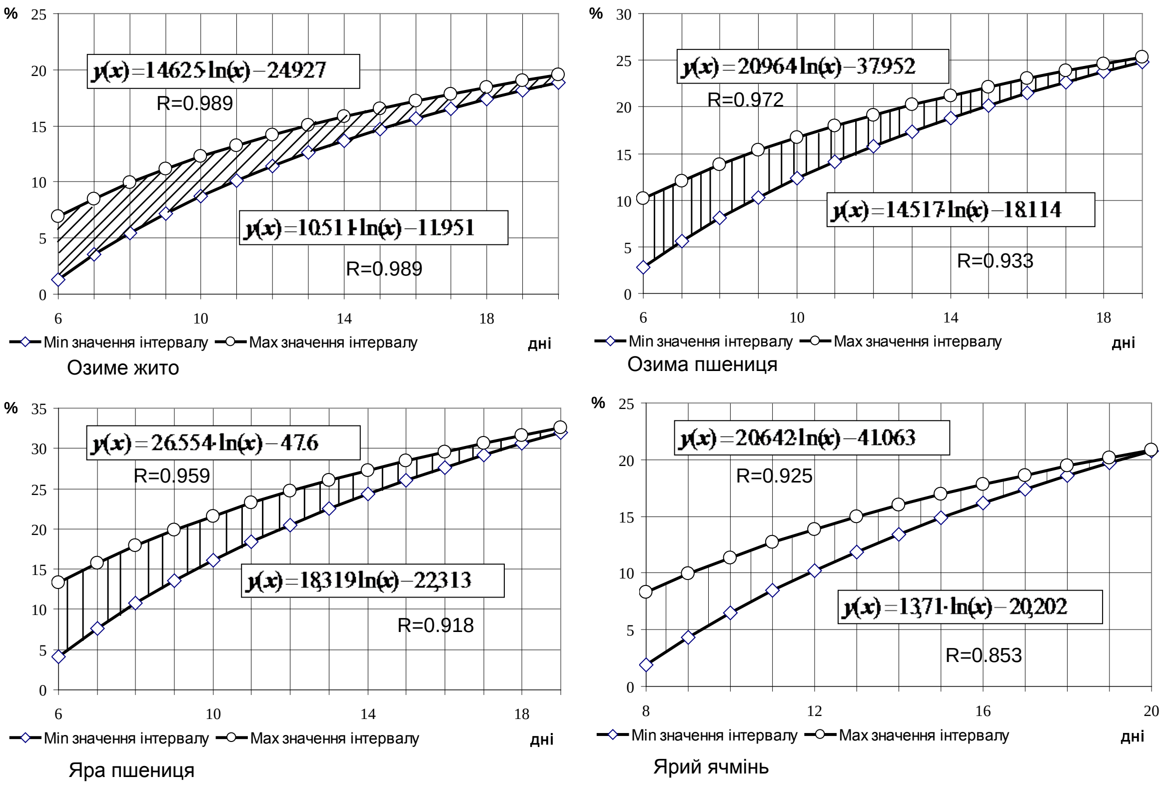

Fig. 5. The pattern of changes in biological grown crop losses depending on the period of collection.

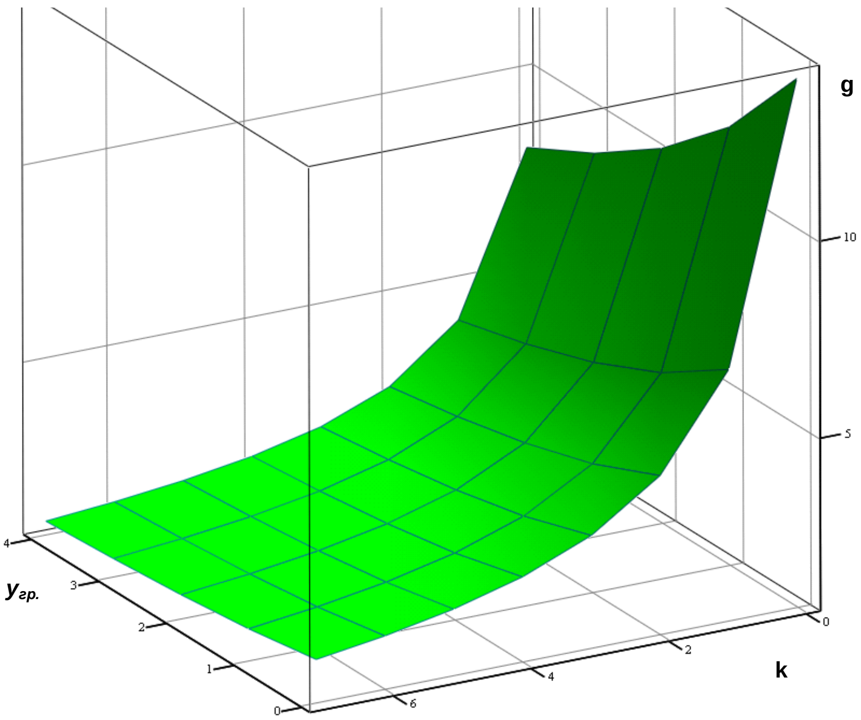

Fig. 6. The intrinsic bandwidth dependence of grain shattering coefficient (k) and threshold value losses on SMEs.

Statistical analysis of numerical values relative yield losses from shattering y (x) of length harvesting possible to obtain empirical dependence for max i min interval values:

1. Winter rye: max $y(x) = 14.625\ln(x) - 24.927$, $R = 0.989$; (21)

   min $\boldsymbol{y}(\boldsymbol{x}) = 10.511\,ln(\boldsymbol{x}) - 11.951$, $R = 0.989$. (22)

2. Winter wheat: max $y(x) = 20.964\ln(x) - 37.952$, $R = 0.972$; (23)

   min $y(x) = 14.517\ln(x) - 18.114$, $R = 0.933$. (24)

3. Spring wheat: max $y(x) = 26.554\ln(x) - 47.6$, $R = 0.959$; (25)

   min $y(x) = 18.3191\ln(x) - 22.313$, $R = 0.918$. (26)

4. Spring barley: max $y(x) = 20.642\ln(x) - 41.063$, $R = 0.925$; (27)

   min $y(x) = 13.71\ln(x) - 20.202$, $R = 0.853$. (28)

Conclusions

Theoretical studies of productivity of mechanical losses the following conclusions:

1. Graphical dependence is shown in Fig. 1, Fig. 2 can occur when crops are ripe and in a state of "peace" within 5-6 days ahrostrokiv harvest when the natural shedding is within 0.01 ... 0.05% of the gross yield on projected area for collection provided that the culture matures at the same time. Laws agrobiology claim. With 4.5 million stems of winter wheat are at1 ha area can not mature at the same time, that the initial rate of natural shedding more than 0.1% of the gross yield because the tracker performance of mechanical losses similar to that shown in Fig. 1, Fig. 2.
2. For analytical expressions 15 The dependence of mechanical performance of allowable losses for IPS combines (Fig. 4).
3. Analytical research point of inflection curves productivity through bandwidth depending on the adopted numerical values of the losses and increase the relative values of limiting losses.
4. When comparing the relative values of biological losses from shattering of relative numerical values and allowable losses for IPS LC 20-day harvest turned out that biological loss in volume 18..19% higher than the allowable mechanical losses in the amount of 1.5% at 12 for winter rye times, 16 times for winter wheat, 21 times for spring wheat and 14 times for spring barley. Comparison of actual losses. Recorded during the harvest by combine harvester DON-1500 that the average value does not exceed 0.6% indicate that biological losses exceeding 20 days of harvest mechanical losses within 20 ... 40 times.
5. Weight loss by mechanical IPS combines the average value is 0.6% of the gross yield, ie, 6 kg collected from each ton of grain. Market Value 6 kg is about 11 USD. The cost of 1 ton of food grain at $ 20 more expensive than fodder production, which is formed through delaying

harvest. Losses incurred by farmers on quality losses at each tone, without loss of biological shattering, is approximately 200 USD. That 18-20 times the mechanical losses 11 USD.

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Theoretical proposals dependence producer of combine-ness zernouborochnыh from mechanical Potter, voznykayuschyh by threshing-separyruyuschym devices. Opredelena harakterystycheskaya dependence bandwidth abilities from HCC durations Other cleaning through utilization rate osыpanyya grain and rubbed predelnoho value for ISU.

Proyzvodytelnost, propusknaya Ability, osыpanye grain threshing-separyruyuschee prysposoblenye.

The theoretical dependence of production grainharvesters combine from mechanical losses arising for threshing and separating device. The characteristic dependence of capacity of duration of grainharvesters combine factor shedding through harvesting grain and limit losses in threshing and separating device.

Production, capacity, shedding grain, threshing-separating device.