UDC
631.354.2

Determine the residual capacity and load factor MOTOR DEPENDING FROM operational performance and condition

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Utochnotin dependency calculation speed of the combine harvester (HCC) with regard to actual engine power and dynamics of HCC. Defined permissible values for operating speeds Speed thresher.

Co.mbayn balance of power, productivity, bandwidth, load, engine, thresher.

Resolutionska problem. The literature in the calculation engine power is considered as a constant. In real operation conditions but with the increase in operating time Hours engine power is reduced due to general wear cylinder-piston, gas distribution mechanism elements of the fuel system and the total rozrehulovanosti.

AnaLease Finalnnih dperssurvey findings. In the formulax atled to the literature [1, 2, 3, 4], which calculated the productivity of mobile units, engine power is introduced constant value (1), and that does not change with increasing operating time in Hours, ie the useful life in years during which implemented operating time:

$$Wz_m = \frac{C}{K_{and}} \bullet N_e \cdot \xi_{Ne} \cdot \eta_{TP} \cdot T_p \ , \qquad (1)$$

de C - conversion factor; Ka – specificand resistance ITA kN / m; Ne - powering the engine, KW; ξ_{Ne} -Stupining capacity utilization (degree download); η_{TP} - CCD transmission; Tp – nettime and work hours.

Dla VHIncas sweatzhnosti Effectsvnosti IRyhuto toykorylast one introduced load factor ξ_{Ne} afteraboutvirnisnym value does not bythose from its technical condition, the actual loading thresher and power costs on the motion.

By Showingtion withpetsiaLiszt daboutevidence mechanicsters sent to UMOIslands toyrobtion A reductiontion a powerfulness proyavlyayetsya alternationfrom

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fromhumiliation operating speed the transition to a lower gear, from 3rd to 2nd to 1st gear, which directly affects the performance variable hour.

By EID-identification Fdanovskoho NS [5] parameprop- engine failure is called a parametric state in which sweatzhnist Turbocharged engine without reduced by 7-8%, and Turbocharged reduced by 12-13%.

DA SMD-31A engine at rated power $Ne_{Categories}$= 235 hp (173 kW) fromhumiliation sweatzhnosti to 19% (to withtanin failure) Lakenachatyme 45 hp the actual power N_f= 190 for.s. (152kVt). EIDnachyty state parametric failure to reduce power by subjective indicators without special diagnostic devices virtually impossible. Therefore, in the field are tractors, combines with the engine power reduced to 30% of the nominal value.

Metand dperssurvey findings. Noiseth daboutfor Research Blvd.about toyznachetion andmovirnyh numerical values and harmonic fluctuation component of uneven productivity hlibostoyu the area of the field and its influence on the load thresher.

Obviously, the reduction in engine power even combine 23 ... 24 hp affect hour shift and productivity through fromworking shvydkoste humiliation and a crackdown on loading thresher combine to optimal throughput.

Rezultaty dossurvey findings. AboutPowered by toslidzhennyamy [6] found that reducing the rotational speed beater from 2000 to 1700 rev / min. while supplying meat weight of 2 kg / s. (Yield 2,5t / ha., Grain moisture ≈ 16%, 19% straw, solomystist 1 ... 1.3) increasing losses threshing instrument to 3.5%, reduced productivity combine to 0.6 ha / h.

One of the reasons for the decline threshing speed can be a reduction in engine power through rozrehulovanist or wear tsylindro-piston or shared their action.

Combines equipped with one engine essentially combined in a two-car - threshing machine and chassis. Work thresher requires maintaining constant speed of mechanisms fluctuations which do not exceed 5-7% [6]. This is due to the provision of quality indicators threshing and separation. Working Chastyna requires 40% of the energy of the engine, the rest of which is spent on the execution of the process. Therefore, performance LC tight engine power.

The basic equation that describes the work beater onv'yazuye engine power N_e charactersjoints Drum r_iAnd ongiving the meat mass

q_i:

$$N = And\frac{d\omega}{dth}\omega = \frac{q_i \cdot r}{1-\phi}. \quad (2)$$

Costs sweatzhnosti to odesnytsyu overhaulschopped mawithand determined from the relationship:

$$\frac{N}{q_i} = \frac{V^2}{1-f} = \frac{\omega^2 \cdot r\,2}{1-f}. \quad (3)$$

In formulas driven nominal capacity. Obviously, with a decrease in engine power is reduced angular speed of the drum, and thus reduces the number of processed supply. To ensure the stability of the process while reducing engine power is necessary to reduce the supply of meat to the weight of the drum by reducing the operating speed or width Reaper (VR).

Potzhnist IRyhuto toytrachayetXia to Providetion robotand thresher and chassis:

$$N_e = N\,m + N\,p\,. \quad (4)$$

Technology of thresher conservation requires constant speed mode of its mechanisms, ie, constant speed, the vibrations of which should not exceed 5-7%. Such requirements dictated by the need to ensure quality in the performance of threshing and separation.

GaitIslands of how consumer power, characterized by its primary purpose - providing power thresher. Therefore, the magnitude of power required to move the combine is directly dependent on the mode of thresher.

Productsness harvester can equal billing and constructive bandwidth thresher:

$$q_{aboutFri.} = \frac{V_p \cdot In\ the_p \cdot Q_{from}(1+\gamma_c)}{360}. \quad (5)$$

Yesand Productsness moDPOresponsible propskniy fromdatnosti and providedI work appropriate speed:

$$Vp = \frac{360 \cdot qo_{Claims} \cdot Q_{from}(1+\gamma_c)}{In\ the_p}. \quad (6)$$

Wvydkist movement at all constants defined Agrobiological withandNom xlibnoyi weightand, That is,about urozhaynistyu and solomystistyu meat weight $Q_{from}(1+\gamma_c)$. With this speed is effective sweatzhnist engine for movement and maintenance of thresher spent 100%. When the combine performance per unit of time below capacity thresher remains

unused capacity of the engine, which is taken into account in the formulas coefficientsiyentom capacity utilization - □N (7).

$$V_p=\frac{3.6\left(\frac{Ne_{Categories}}{1.36}\right)\cdot\xi_N - N_p}{\frac{C_{mk}\left(f+\frac{i}{100}\right)}{\eta_{May}}+\frac{B_p\cdot Q_{from}(1+\gamma_{with})N_{pyt}}{10}}. \quad (7)$$

The significance of the engine load factor based on actual power look through the balance of power. In general, the balance of engine power harvester determined by the equation:

$$N_e= N_x + N_m + N_p \mp N_y \pm N_n + N_{from}. \quad (8)$$

where – EffectsVNA engine power, kW; Nx – sweatzhnist for Ne idle about working bodies combine kW; Nm -sweatzhnist, necessary for providing process combine kW (without N_x); N_p- sweatzhnist, zatracheto Categoriesand replacement combayna, kW; N_y - Power spent to overcome biases combine, KW; Nn - sweatzhnist to onovercome supportsin onwinds, kW; N_{from} - Residualand sweatzhnist motor kW.

Given that the flat portion of the field $N_y= 0$And at low speeds $N_n= 0$We obtain:

$$N_e= N_x + N_m + N_p + N_{from}. \quad (9)$$

RoseLet us consider the importance of each component of the balance. Engine power, which is necessary to drive a bachelor working arrangements (Nx), can be expressed through the equation:

$$N_x=\frac{1}{9550}\sum_1^i\frac{Mx_i\cdot n_i}{\eta_i}. \quad (10)$$

where Mx_i,n_i,η_i - Kruttion momoment (Nm) rotationand(V / vc) and K.KD. appropriate working arrangements.

Prand the engine speed characteristics of the regulatory branch is supported regime of control. Therefore, with reasonable accuracy; practices can be considered for power on blank drive working arrangements constant $N_x\cong const.$

In the processing unit and moving-zero Agrobio filing certain logic state of the evening mass necessary for each worker mechanism m_iKruttion of the engine or $N_i$delayt power necessary for separation, transport and recyclingand can determined from the equation:

$$N_M = \frac{q}{9550} \sum_1^i \frac{m_i \cdot n_i}{\eta_i} + \frac{q \cdot m_{to} \cdot n_{to}}{\eta_{to}} = q\sum_1^i \frac{N_i}{\eta_i} + qNpy_t. \qquad (11)$$

where $N_i, Npy_t, m_{to}, NB, \eta_{to}$ - specificand sweatzhnist kVt witheq./kh., specificand Twistedand time Nm sec. / kg., turns / min. and efficiency drum.

Potzhnist necessary to ensure process can be determined through specific supply the meat mass q kg / sec. and specific consumption of power *N*$_{demand}$ kVt s / kg:

$$N_M = q \cdot N_{demand} = \frac{B \cdot U(1+\gamma_p)N_{with\ demand}}{36} = \left(\frac{B \cdot U(1+\gamma_p)N_{with\ demand}}{10}\right) \cdot \frac{B_p}{3.6}. \qquad (12)$$

where: *U* - urozhaynist t / ha; γ_c -solomystist.

According to AJ Polyakov [1], the value of the power needed for separating and transport mechanisms *NCm* practicalbut does not depend on the speed of the combine and feeding the meat mass and can take constant:

$$N_{Cm} = \frac{q}{9550} \sum_1^i \frac{N_{demandi}}{\eta_i} = const. \qquad (13)$$

Andfrom equation (11) implies that power is needed for workflow depends on basic consumer power of the drum.

Andthe expressions (10) and (13) we can write:

$$N_{CTx} = N_x + NC_T = const. \qquad (14)$$

where *Nh* - The power required to drive all idle workers orgabers and the workingth processin (Crafter *N6),* kW; N_{CTx} – sweatzhnist, required dlI Providetion robochohabout processin Separatingx tand transport mechanisms kW.

By inas *Nh = const ',NCm= Const* aboutAIN customers sweatzhnosti is drum thresher and chassis combine.

Considering the major consumers of power balance of the engine will be determined by the equations:

$$N_e = N_p + N_t + N_{Ct} + N_{from}, \quad N_M = N_{to} + N_{Ct},$$

$$N_e = N_p + N_M + N_{from}. \qquad (15)$$

Costs sweatzhnosti combayna Categoriesand toyznachayutsI pyx from bydependence:

$$N_p = \frac{q \cdot C_t}{\eta_{May}} \left(f + \frac{i}{100} \right),$$

where f - coefficient of rolling; *i* - nahil field if *i* = 0.

$$Np = q \cdot G_k \cdot \eta \frac{f}{May}. \qquad (16)$$

Toslidzhennyamy [8] was determined costs for power combines movement, depending on the characteristics of the field.

1. Effect Specificationsfor PollI to a powerfulness motionincombayniv.

MArch komba - yna	Mace in tion of full Categ oriesa van-	Xarakter field surface		The velocity V, km / h.	Moment on the navigation wheel, Mark, kN m.	Power spent in traffic, N, kW
		In theEid	Kut rise. deg.			
Don 1500	17800	Stern	±0.3	3.00 ...	8.0 ... 9.0	6.5 ...
		Stern	+6.5	5.00	25.2 ...	17.0
		Stern	+8.0	2,70 8,10	28.7	17.5 ...
		Road	±0.3	...	24.6 ...	71.0
KD-116		Stern	±0.3	2.66 ...	34.5	47.0 ...
(FRG) E516	18500	Road	±0.3	4.13	9.0 ... 12.8	75.0
		Stern	±0.3	9.00 ...	17.4 ...	20.0 ...
(GDR)	15	Road	±0.3	11.16	26.5	36.0
870				11,80 10,0	6.5	8.5 ...
				...	17.0	15.0
				27.0	8.6	18.0 ...
				9.7		20.0
				19.8		8.1
						18.0

If engine power as a result of general wear and tear rozrehulovanosti fromand couplemetric indicatorm reliability ΔN_P fromnyzhena of the nominal value *Nen* the actual N_f:

$$\Delta N_P = Ne_{Categories} - N_f. \qquad (17)$$

where ΔNP – from-identification of parametric engine reliability.

Tabout ochevybottom from-identification Balancesing sweatzhnosti tacossame frommenshytsya the ΔN_P: magnitude

$$N_{from} = N_e - N_p - N_M - \Delta N_P. \qquad (18)$$

Reduced residual capacity must be considered in the probabilistic by engine load factor in calculation formulas.

RoseLet us consider the possibility of regulatory characteristics to replace the engine load when the motor harvester and thresher work.

Prcombine work and can be uneven load Barabooon at ± ΔN_P and uneven load movement

Categories and ± ΔN_p.

Taking into account the reduced peak potential and downloads

Babalance of power can be written:

$$N_e = (N_p \mp \Delta N_p) + [(N_M \pm \Delta N_M) + N_{From}]. \qquad (19)$$

Andfrom pivnyannya (19) mozhna toyznachytand from-identification residual sweatzhnosti

$$N_{From} = N_e - (N_p \mp \Delta N_p) + [(N_M \pm \Delta N_M) + NC_P]. \quad (20)$$

3, taking into account equations (19) and (20) the actual value of the remaining capacity will be:

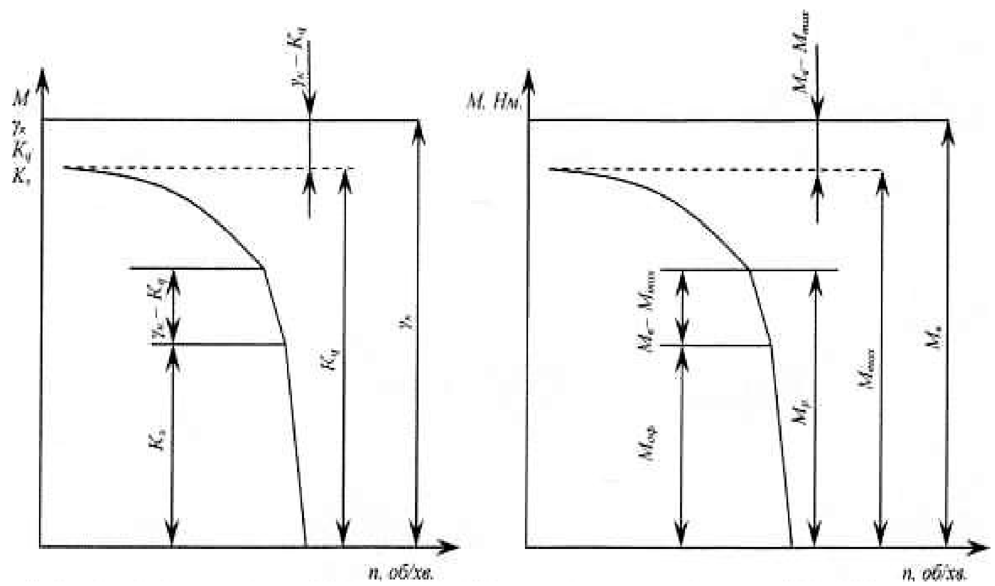
$$N_{From} = N_e - (N_p \mp \Delta N_p) + [(N_M \pm \Delta N_M) + NC_P] - \Delta N_P. \quad (21)$$

Neustanovlenyy nature leads to fluctuations in load moment of resistance. Therefore, the load of the engine at full or close to it inevitably causes a power switch on the engine operation without regulatory area characteristics.

Poyasnennya engine load factor based on available research Boltinskoho VN [7]. To determine the degree of loading of the engine author proposed a formula for determining the load.

$$K_{From} = 1 - (\gamma_{with} - K_d). \quad (22)$$

dth γ_{with} – koefitsiyent mozhlyvohabout supportsfor overload; K_d - koefitsiyent permissible overload.



Ric. 1. Characteristics of the combine at neustanovlenomu loaded.

Toslidzhennyamy Boltinskoho VN shows that the coefficient overload $K_d$byis a significant number of factors. These include design features of the engine, the amount atled to the crankshaft moments of inertia $\left(M = \frac{d\omega}{dt}\right)$ Frequency frommines moment of resistance on the motor shaft, the degree of unevenness.

Load factor is determined from the equation:

$$\text{With } K = \frac{M_{d.Wed}}{M}, \quad (23)$$

p

where M_{DSp} – Sulfurdnye identification dopustimulated from-supportsin IRyhuto; M_p- Calculationsve (nominal) value of torque.

Average allowable torque values:

$$M_{d.sp} = M_p - (M_{to} - M_{max}). \qquad (24)$$

The joint solution of equations (23) and (24) gives the expression:

$$K_{from} = 1 - (\gamma_{to} - K_{Section}). \qquad (25)$$

where $\gamma_{to} = \frac{M_{to}}{M_p}$ – coefficientitsiyent possible overload dvyhuna;

$K_{Section} = \frac{M_{max}}{M_p}$ – coefficientsiyent adaptation engine.

If we express the load factor of the engine (23) through rate adaptation and the degree of uneven resistance change engine get:

$$K_{from} = \frac{K_{Section}}{\gamma_d}, \qquad (26)$$

where $\gamma_d = \frac{M_{max}}{Mp}$ – coefficientitsiyent possible increase torque engine (point of resistance).

The degree of increase in torque output:

$$\gamma_d = \frac{M_{max}}{M_{d.Wed}} = \frac{M_{d.Wed} + \Delta M}{M_{d.Wed}} = 1 + \frac{\Delta M}{M_{D.Wed}}. \qquad (27)$$

The degree of uneven torque;

$$\delta_d = \frac{2\Delta M}{M_{d.Wed}}, M_{d.Wed} = \frac{2\Delta M}{\delta_d}. \qquad (28)$$

Pidstavyvshy (28) in equation (27),willmo:

$$\gamma_d = 1 + \frac{\delta_d}{2}. \qquad (29)$$

In theidpovidno engine load factor is:

$$K_f = \frac{K_{Section}}{\gamma_d} = \frac{K_{Section}}{1 + \frac{\delta_d}{2}} = \frac{2K_{Section}}{2 + \delta_d}. \qquad (30)$$

On the recommendations of the authors of [8] better brotherand withtceYin uneven krutnohabout IOMentin and rms deviation equal to the value of the shafts about working mechanisms.

Consideringand duration of exposure uneven torque controller will respond torque fluctuations within the standard deviation. The coefficient of variation

middle	meanstion	maboutment	supportsin	Categoriesand
	bankin	dvyhunand	mozhnand	

define a relationship:

$$\delta = \frac{K_{to}}{5 0\%}. \quad (31)$$

Pidstavymo (31) in the expression (30) and obtain:

$$K_{from} = \frac{100 K_{Section}}{100 + K_{to}}. \quad (32)$$

AndAnalysis shows that due to stock torque given factor byloading dth diFriand to limitsandx short termmennyh reloaded with drum ΔN_{to} and s h o r t term overload prand movement of a combine harvester while driving ΔN_ple within the reserve Kruttion since the regulatory characteristics of the engine, not within the residual power.

Residual engine power, within which you can change coefficientsiyent load a different expression. Effective power distribution between threshing instrument chassis and harvester at work can be shown in Fig. 2, Fig. 3.

DTo explain, we assume that combine working in a hospital (Np □□ 0), That is,about pratsyuyutb mthnisms molotarky asand consumptioning thnerhiyu (power) engine - a drum (NB) and separating - transporting bodies and their blank drive.

Residual sweatzhnist (N_{from}) to Tacomain droppedSTU buwhere the maximum, and coefficientitsiyent byloading IRyhuto (ξ_N) minimal.

$$N_{from} = N_e - (N_{to} + \Delta N_{to}) - N_M - N_x. \quad (33)$$

Costs sweatzhnosti tion fromare lishyao respectivel to Sectionidvyschennya speeds combine. When specified yield $U_{from} \cdot (1+\gamma_{with})$ prand increasing the speed of the combine Vp daboutsyaha yetsya g_{opt} optimaximal value of the capacity of the combine.

In the thisin Shufflein byresidual Potuzhnist IRyhunand dOpivnyuye $N_{from} = 0$And a load factor of engine $\xi_N = 1$.

RoseLet us consider the boundary value of the residual power of the engine, the maximum residual capacity N_3=max will combine the conditions of work at the hospital when the engine power to move the combine *Np*= 0. The residual capacity when working in a hospital may 70 kW. In terms of real operation indicator of changes in engine power is to reduce operating speeds and combines boundary change engine load factor.

Equation (6) can not determine the effect of engine power quantitative values of the speed of the processor. Explore the impact of changes in engine power through speed of the combine andnalitychni dependence, including engine power. For self-propelled machines accepted that the engine power is determined from the dependence [9]:

$$N_{pyw} = [G_{mk} \cdot f_0 \cdot (1+ \rho(V_p - V_0))] \cdot \frac{V}{3.6}. \quad (34)$$

Andof dependence (5), (6), (8), (12) and (16), (34) define N_e:

$$N_e = NC_T + N_{from} + \left[\frac{G_{mk} \cdot f_0 \cdot (1+\rho(V_p - V0))}{\eta_{May}} + \frac{\text{In the}_p \cdot U \cdot (1+\gamma) \cdot Npyt}{10}\right] \cdot \frac{V_p}{3.6} =$$

$$= NC_T + N_{from} + \frac{10 \cdot V_p \cdot G\,mk \cdot f_0 + 10 \cdot V_p^2 \cdot f_0 \cdot \rho \cdot G\,mk - 10 \cdot V_p \cdot V_0 \cdot \rho \cdot G\,mk \cdot f_0}{\eta_{May}} + \quad (35)$$

$$+ \frac{V_p \cdot \text{In the}_p \cdot \eta_{May} \cdot U \cdot (1+\gamma) \cdot Npyt}{36 \cdot \eta_{May}}$$

Pislya several transformations and marking:

$$A_1 = \frac{10 \cdot Gmk \cdot f_0 \cdot \rho}{36 \cdot \eta_M}. \quad (36)$$

tand

$$A_2 = \frac{10 \cdot G_{mk} \cdot f_0 \cdot (1 - \rho \cdot V_0) + B_p \cdot U \cdot (1+\gamma) \cdot N_{demand\ tp} \cdot \eta_{May}}{36 \cdot \eta_{May}}. \quad (37)$$

nd

The final equation is:

$$V_p^2 \cdot A_1 + V_p \cdot A_2 - (Ne_n - N_M) = 0. \quad (38)$$

Andfrom pivnyannya (35) define byresidues sweatzhnist dlI Categoriesthfrombodypack (-regulated) engines:

$$N_{from} = N_{thCategories} - N_M - V_p^2 A_1 + V_p A_2. \quad (39)$$

DA worn and not vidrehulyuvanyh engines:

$$N_{from} = N_{thCategories} - N_M - \Delta N - V_p^2 A_1 + V_p A_2. \quad (40)$$

EIDnachymo V_p ccandspite, uabout towithI sweatzhnist dvyhunand taken to speed:

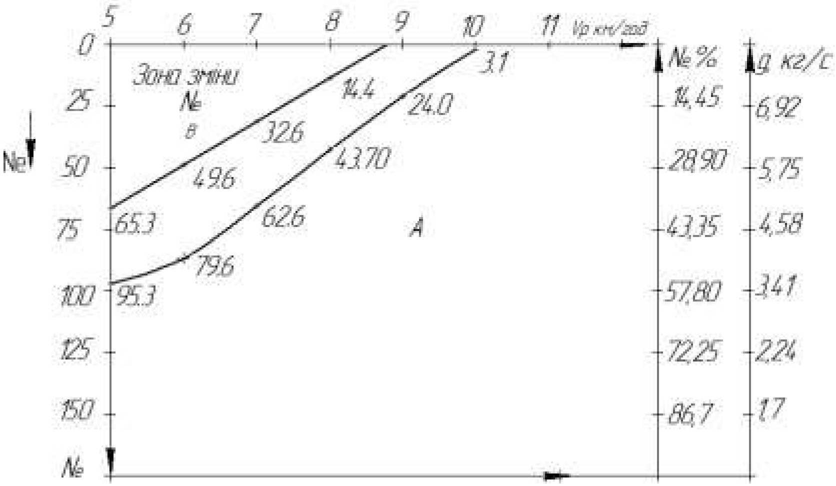
$$V_p = \frac{-A_2 \pm \sqrt{A_2^2 + 4A1(Ne_{Categories} - N_M - \Delta N)}}{2A1}. \quad (41)$$

Vplil power change in the rate calculated by the formula (7) And (38) combines shown in Fig. 2 and Fig. 3.

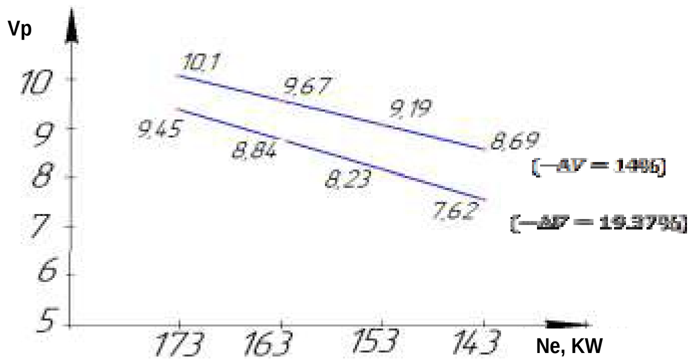
Calcsettlements coefficient And_2 fromled in the table. 2.

2. From-identification factor And_2 depending on yield (C) T / ha.

Fatist (c) t / ha	2	3	4	5	6	7
coefficient And_2	879	12.64	15.72	18.74	20.55	21.76
And_2^2	77.24	15965	24738	35155	42256	47363



Ric. 2. Dependence of residual changes in engine power of HCC wvydkosti movement and actual power Ne_f:And obFins use sweatzhnosti in HCC and thrashing motion; B-domain residual engine power.



Ric. 3. Patterns of change of velocity of HCC parametric engine reliability at U 2 t / ha.

Conclusions

For Some formulas can calculate the numerical values of the residual capacity depending on the state of Agrobiological meat supply, productivity, technical condition of the engine, the speed of the HCC and to determine the allowable region changes and factor byLoading Engine N_eWhich can vary only within a byresidual capacity (Fig. 2).

Uselast one formula (41) can more accurately calculate the speed motionin from Inclaccount the factualtion sweatzhnosti dvyhunand and dynamics of HCC permissible values for operating speeds Speed thresher (Fig. 3).

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Utochnotin dependence calculation Speed Motion zernouborochnoho combine (HCC) with uchetom faktycheskoy-power engine dynamics and movement HCC. Opredelenы dopustymыe predelы workers velocity values for optimization Downloads threshing machine.

Co.mbayn balance-power, yield, propusknaya Ability, Search engine, threshing machine.

The elaborated dependency of calculation to velocities of motion grainharvesting combine (GC) with provision for actual engine size and speakers of motion GC. The possible limits of importance's worker velocities are determined for optimization of oading the thresher.

Combine, balance to powers, productivity, reception capacity, loading engine, thresher.

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LowersIng dynamic forces in the bridge crane BY optimization of the crane

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