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**Lukianchuk O. P., Candidate of Engineering, Associate Professor,
Zahurskyi A., Master's-degree Student** (National University of Water
and Environmental Engineering, Rivne)

RESEARCH OF PERFORMANCE OF THE WORKING BODY OF THE SINGLE-BUCKET BACKHOE EXCAVATOR

The work is devoted to the research of the efficiency of working body of the single-bucket backhoe excavator. In master thesis the analytical analysis of previous studies process of single-bucket excavator was conducted, the parameters of specific power consumption and the development of soil by excavator were determined.

Keywords: power consumption, performance, digging, cutting, efficiency, soil.

Purpose. In construction, hydromelioration and at open mine workings, massive earthworks occupy a leading position. The importance of improving the efficiency of construction equipment is due to significantly reduced cost of manual labor.

The experience of excavators operation proves excessive wear of the tines and cutting edges of the bucket, improves soil cutting power capacity by 1.4 - 3.0 times, reduces productivity by 10-40%, resulting in economically advantageous further operation. In metal structure of the equipment the loads arise that increase tension in 1.1 - 1.8 times. Timely replacement of tines when reaching the limit of wear reduces the development cost price of 1 m³ of soil by 18-20% [1].

Findings. In this section, all of the above described items are on the whole based on the theories of soil cutting such as Horyachkin, Dombrowsky, Vetrov. The most rational way to determine the effort while cutting the ground with different angles of excavator tines sharpening is expressed by Vetrov theory is based on the process of space and manifests itself in the destruction of soil as trapezoidal apertures, which has the greater width than the width of the blade [2; 3].

Methodology. Objectives of the study. the eventual establishment of the ways that would reduce the power consumption of the excavator [4].

To achieve goal the following tasks were carried out:

- Making analytical analysis of the previous studies of single-bucket

excavator operation.

- Determining the weight parameters for power consumption and process performance in developing soil by excavator.
- Researching the power consumption of the excavator with digging working equipment "backhoe".

Originality. In the work we described the general principles of single-bucket excavators, main productivity of single-bucket excavators, resistance to blunting depending of the angle of inclination on the wear platform, increasing of single-bucket excavators tines durability, considered experimental cutting theory of soil.

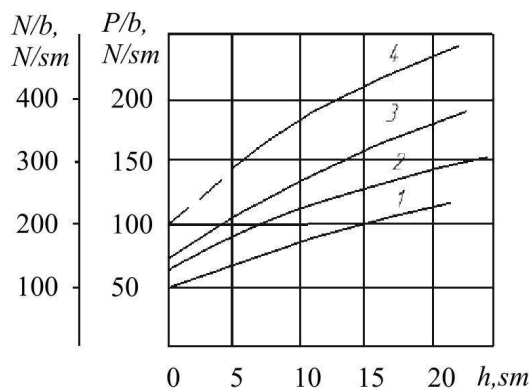


Fig. 1. Dependence of additional (tangent- - , normal -) resistance forces to the destruction of the depth of cutting for different areas across the width of wear: 1,2 - $b = 40$ mm; 3,4 - $b = 70$ mm; 1,3 - for ; 2,4 - for N

Also much attention is paid to cutting elements blunting and its impact on the process of digging the soil. The experience of the operation of excavators, excessive wear of the tines and cutting edges of the bucket improves power capacity of the cutting soil by 1.4-3.0 times, reduces productivity by 10-40%, resulting in not economical advantages in further operation.

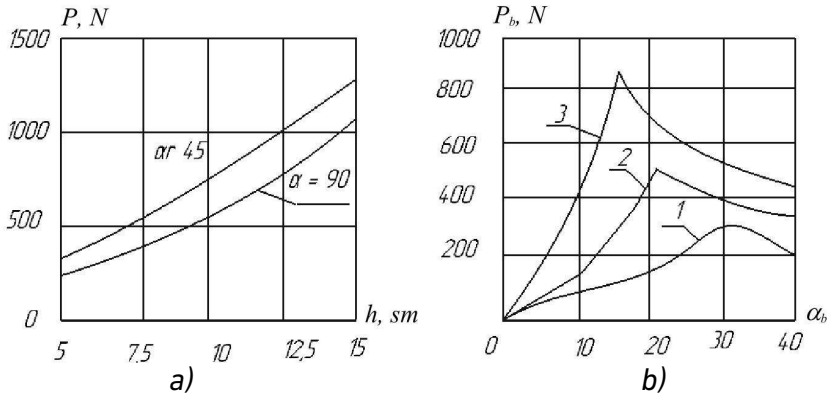


Fig. 2. Dependence of change
 a) resistance cutting sharp tines on the cutting depth,
 b) cutting force from the blunt angle

Displacement occurs when the effort necessary for soil compaction before using tines, as compared with the effort, required to shift the soil.

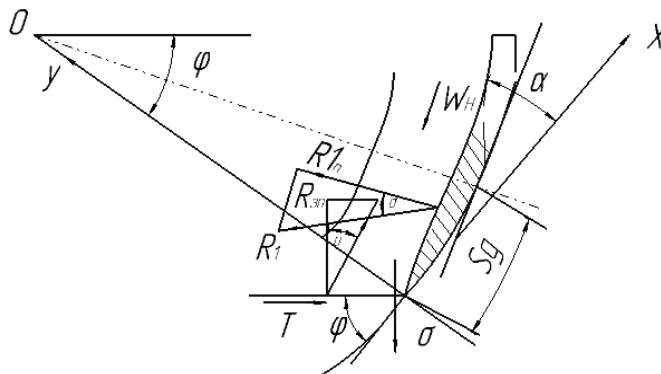


Fig. 3. Active force on the tines when shifting soil

On the element that shifts the tine forces R_1 act, reaction of massif R_2 resistance at the site of displacement T , resistance of filling W_H , element weight G . Efforts R_1 and R_2 , deviated from normal on the angles of the external and internal friction.

In the work deals with general information about the process of digging with a "backhoe" which calculated performance of the excavator, power consumption of the process, specific energy digging, the range of variation components of energy and process performance for excavator EO-4121, determining the impact value on energy and digging performance, power consumption performance approximation formulas, determining dependencies of performance and power

consumption of digging through the most significant parameter. It suggests the calculation of average effort of soil resistance.

Performance excavator, m^3/t :

$$P_e = q \cdot k_n / k_p \cdot t_c = B \cdot S_b \cdot k_n / k_p \cdot t_c, \quad (1)$$

where k_n – bucket filling ratio; k_p – rate of loosening the soil; t_c – cycle, t ; B – bucket width, m ; S_b – lateral area of the bucket, m^2 .

$$t_c = t_k + 2t_p + t_v, \quad (2)$$

where t_k – duration digging, t ; t_p – turning length, t ; t_v – duration of discharge, t .

$$t_k = \frac{4 \cdot S \cdot Q}{\pi \cdot D^2}, \quad (3)$$

where S – move the piston rod hydraulic cylinders, m ; Q – working fluid consumption, m^3/t ; D – diameter piston cylinder, m .

$$P_e = \frac{B \cdot S_b \cdot k_n}{k_p \cdot \left(\frac{4 \cdot S \cdot Q}{\pi \cdot D^2} + 2t_p + t_v \right)}. \quad (4)$$

Working digging the soil:

$$A = k_1 \cdot q \cdot \alpha, \quad (5)$$

where q – bucket capacity, m^3 ; k_1 – resistivity digging; α – correction factor.

$$A = B \cdot S_o \cdot \alpha, \quad (6)$$

Power consumption, kW/m^3 :

$$E = A/P, \quad (7)$$

$$E = \frac{k_1 \cdot B \cdot S_o \cdot \alpha}{B \cdot S_o \cdot k_n \cdot k_p \cdot t_c}, \quad (8)$$

$$E = \frac{k_1 \cdot \alpha \cdot k_p \cdot \left(\frac{4 \cdot S \cdot Q}{\pi \cdot D^2} + 2t_p + t_v \right)}{k_n}. \quad (9)$$

Table 1

The range of components change

Components	Value	Average value	Units of measurement
k_1	18...400·10 ³	210	Pa
α	1,1...1,4	1,25	-
k_H	1,15...1,3	1,2	-
k_p	1,1...1,4	1,25	-

Table 1 (Continuation)

k_B	0,8...0,9	0,85	-
S	0,6...1	0,8	m
Q	0,04...0,08	0,06	m^3/c
D	0,1...0,018	0,14	m^2
t_n	4...6	5	S
t_B	3...5	4	S
t_n	2...3	2,5	S
S_6	0,625...1,51	1,07	m^2
H	0,4...0,825	0,6125	m

Definition of the value is performed by the coefficient of correlation, the general formula being:

$$r_{xE} = \frac{S_{xE}}{S_x S_E} = \frac{\frac{1}{1-n} \sum_{i=1}^n (x_i - \bar{x})(E_i - \bar{E})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (E_i - \bar{E})^2}}$$

where x_i – setting that explores; E_i – power consumption; S_x , S_E – variables for x and E respectively; S_{xE} – covariance moment.

After receiving all values of correlation coefficients there was constructed the following histogram.

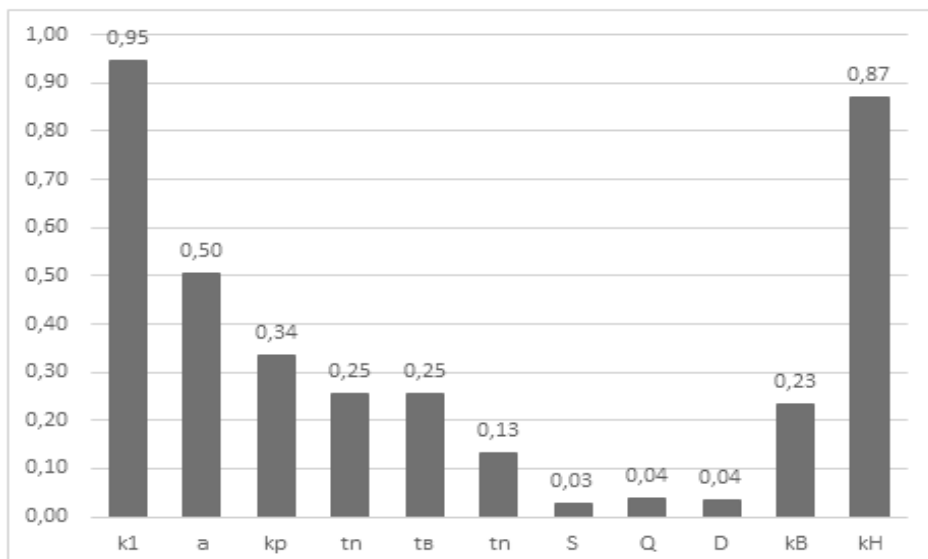


Fig. 4. Histogram of correlation coefficients for power consumption of digging

The histogram shows that the greatest impact on energy has the specific resistance of digging k_1 .

To determine the formula there was constructed the graph of

dependence of the power consumption of the digging specific resistance on the basis of Microsoft Excel (Figure 5). For doing this some resistance value is chosen (Table 1) and is substituted into the formula (9) for power consumption, all other values are moderated:

Table 2

Values of digging specific resistance and the resulting power consumption

k_1, kPa	18	68	118	168	218	268	318	368	418
$E, \text{kVt/m}^3$	0,11	0,42	0,73	1,04	1,35	1,66	1,97	2,28	2,60

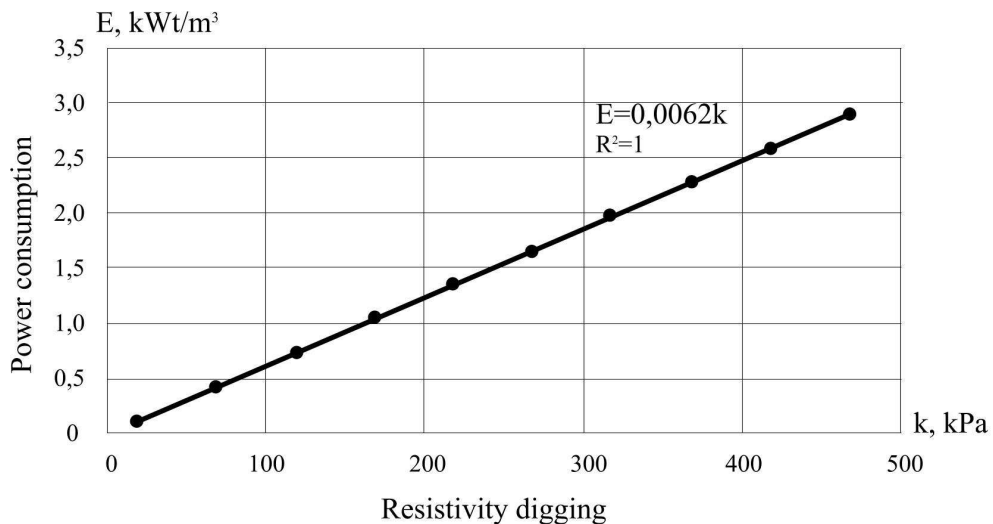


Fig. 5. Graph of the energy content of the digging specific resistance

The research indicates that the most productive mode of operation is digging the soil in which the cutting path and the filling of the bucket will be the lowest. In this case reduced proportion of energy provides more efficient use of earth-moving machines without changing the parameters of working equipment.

Practical value. After conducting the analytical research of cutting the soil at different diameters of blunt and parameters that affect the effort required for cutting, and hence energy, power and performance. It was found that efforts at cutting the soil consumed quite differently depend on the radius of the blunt.

Of theoretical studies indicate that cutting power consumption to reduce soil advisable to develop chips thicker. Although resistance to

cutting such chips will be higher the way from the start of bucket digging to full content will be minimal, and according to the calculations of the work necessary for the soil excavation in general is the least that accordingly leads to lower power consumption of digging process. As the theoretical studies, a large part of the energy expended on overcoming the resistance of friction between the soil and the bucket. To reduce the reliance it requires changing the design parameters of buckets.

Quite a large proportion of the energy is spent on cutting the soil. The process of cutting the soil is a function of many independent variables and before this feature is not fully set, the right solution of the problem reduce energy excavation will remain impossible.

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Рецензент: д.т.н., професор Налобіна О. О. (НУВГП)

Лук'янчук О. П., к.т.н., доцент, Загурський А., магістр

(Національний університет водного господарства та природокористування, м. Рівне)

ДОСЛІДЖЕННЯ ПРОДУКТИВНОСТІ РОБОЧОГО ОРГАНУ ОДНОКІВШЕВОГО ЕКСКАВАТОРА ЗВОРОТНА ЛОПАТА

Робота присвячена дослідженню ефективності робочого органу одноківшевого екскаватора зворотна лопата. В роботі проведений аналіз попередніх досліджень процесу копання одноківшевого ек-

с-

ті та продуктивності при розробці ґрунту екскаватором.

Ключові слова: енергоємність, продуктивність, копання, різання, ефективність, ґрунт.

Лукьянчук А. П., к.т.н., доцент, Загурский А., магистр
(Национальный университет водного хозяйства и
природопользования, г. Ровно)

ИССЛЕДОВАНИЕ ПРОИЗВОДИТЕЛЬНОСТИ РАБОЧЕГО ОРГАНА ОДНОКОВШОВОГО ЭКСКАВАТОРА ОБРАТНАЯ ЛОПАТА

Работа посвящена исследованию эффективности рабочего органа одноковшового экскаватора обратная лопата. В работе проведен анализ предыдущих исследований процесса копания одноковшового экскаватора, определения значимости параметров удельной энергоемкости и производительности при разработке грунта экскаватором.

***Ключевые слова:* энергоемкость, производительность, копание, резанье, эффективность, грунт.**
