METHODOLOGY OF EVALUATION OF ENVIRONMENTAL AND TECHNOLOGICAL PROPERTIES OF THE MOBILE ENERGY MACHINE

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Abstract: *The method of estimation of technological properties of a mobile power tool is presented in the work taking into account the index of its ecological properties. The results of the expert survey are presented to determine the importance of individual indicators in the evaluation of the generalized indicator of the environmental and technological properties of the mobile energy means. Increasing the informativeness of the methodology for evaluating the technological properties of a mobile power tool by taking into account the generalized index of its environmental properties. The structure of the index of environmental properties of depends on the assignment of the estimated energy source and the purpose of the problem to be solved. In our opinion, with a comparative assessment of energy resources as a unit one can adopt the following indicators of their environmental properties. The obtained result shows that today it is more relevant to assess the technogenic impact of a mobile energy facility on the environment than the cost of its implementation unit of work. And with this conclusion, one can not disagree, since the neglect of the impact on the environment in the near future can nullify the economic profit from the production of agricultural products. The evaluation of the importance of individual indicators for a generalized indicator of the ecological properties of a mobile power tool, according to the results of a survey of experts, showed that the most impact is the index of soil consolidation, then mechanical destruction of soil, composition of exhaust gases, pollution of operating fluids, noise, vibration and least impact is a layout diagram of the power tool. The analysis of these indicators allows us to determine which structural-technological or regime parameters of the energy source and to what extent influence the general indicator of its environmental properties. And the more deeply this analysis will be, the most accurate and successful will be proposed constructive-technological or regime measures to improve them.*

KEY WORDS: *TECHNOLOGICAL PROPERTIES; AN INDICATOR OF ECOLOGICAL PROPERTIES, ECOLOGICAL COMPATIBILITY; MOBILE ENERGY TOOL, METHOD OF RANKING INDICATORS.*

1. Introduction

Methods of the theory of technological exploitation allow to carry out a quantitative assessment of the technological level of the mobile power tool, to determine the degree of conformity of its design parameters and technical characteristics, as well as technological properties to the general requirements of the technological process of agricultural production [1-4]. The method of evaluation of technological properties of mobile energy devices is proposed by dt.n. Kutkov G.M. [1] takes into account the most important, aggregated indicators, such as technological universality, productivity, agrotechnical quality and cost of the performed operation, but does not take into account the index of their environmental properties.

It is clear that mobile energy means are one of the main sources of negative technogenic influence on the environment by harmful products of combustion of diesel fuel, leakage of operational lubricating and cooling liquids, mechanical sealing and soil destruction, acoustic influence, vibration, etc. That is why taking into account the generalized index of environmental properties in the methodology for assessing the technological level makes it possible to assess the conformity of this mobile energy source with the technological requirements from the standpoint of environmental safety throughout the complex of agricultural operations, for which it is intended to be used in the machine-tractor aggregates.

But to calculate the indicator of the technological level of the mobile power tool, in this case, it is possible after the weighting factors of each of the generalized indicators will be obtained. Therefore, research aimed at solving this issue is relevant.

2. Preconditions and means for resolving the problem

The method of calculation of the main generalized indicators of technological properties (technological universality, productivity, agrotechnical quality and cost of the performed operation) is sufficiently detailed in [1]. In contrast to the mentioned indicators, the evaluation of the generalized indicator of the environmental properties of a mobile power tool is not sufficiently studied today. In the classical theory of the operation of a machine-tractor park, the index of "environmental compatibility of a complex of machines" is determined by indicators of ecological compatibility: energy content, soil compaction, humus extraction, pollution of the environment [5].

However, in the thesis [6], for example, a more advanced new methodology for defining the generalized "ecological safety factor" (G_{Fes}) is recommended from the influence of the work of the machine-tractor unit on the environment, which is represented in the form of a relative coefficient of deterioration of the sum of the ecological parameters of the work of the latter, attributed to their normative values:

$$G_{Fes} = K_{Ui}\cdot U_{\kappa i}/U_i + K_F\cdot F_{\kappa i}/F_i + SK_{Ti} + K_N\cdot N_{\kappa i}/N_i + \\ +K_{CO}\cdot g_{CO\kappa i}/g_{COi} + K_{CH}\cdot g_{CH\kappa i}/g_{CHi} + K_{NOx}\cdot g_{NOx\kappa i}/g_{NOxi} + \\ + K_{L1}\cdot L_{1\kappa}/L_1 + K_{L2}\cdot L_{2\kappa}/L_2 + K_{L3}\cdot L_{3\kappa}/L_3 + K_N\cdot N_{Kx.x}/N_{x.x} + \\ +K_{CO}\cdot g_{COKx.x}/g_{COx.x} + K_{CH}\cdot g_{CHKx.x}/g_{CHx.x} + K_{отх}, \quad (1)$$

where K_{Ui} – mechanical destruction of soil;

K_{Ti} – pollution by petroleum products;

K_F – coefficient of influence from the pressure of the tractor's propulsion;

K_{Ni} – dimming of exhaust gases;

K_{COi} – carbon monoxide emissions;

K_{CHi} – emissions of hydrocarbons;

K_{NOxi} – emissions of nitrogen oxides;

K_{L1} – internal noise;

K_{L2} – external noise;

K_{L3} – vibration transmitted to the environment by the technical means;

K_{tw} – the weight of technological waste MTA;

$U_{\kappa i}$, $N_{\kappa i}$, $g_{CO\kappa i}$, $g_{CH\kappa i}$, $g_{NOx\kappa i}$, $L_{1\kappa}$… $L_{3\kappa}$ - - control measures in accordance with mechanical destruction of soil, concentration of carbon emissions, hydrocarbons, nitrogen oxides, internal and external noise, vibration;

U_i, N_i, g_{COi}, g_{CHi}, g_{NOxi}, L_1…L_3 - normative values of ecological indicators according to the state standards;

$F_{\kappa i}$, F_i - the specific pressure of the tractor's propulsion on the ground, respectively, during testing and recommended;

$N_{Ki.s}$, $g_{COKi.s}$, $g_{CHKi.s}$ - control measurements of smoke, concentration of carbon monoxide and hydrocarbons, respectively, in exhaust gases at idle speeds of a diesel engine.

It is worth to take into account the results of recent scientific studies in the assessment of the environmental properties of the mobile energy means.

2.1. Purpose of the study

Increasing the informativeness of the methodology for evaluating the technological properties of a mobile power tool by taking into account the generalized index of its environmental properties.

2.2. Methods of research

Dependence on the calculation of the technological level of the mobile power tool, taking into account its environmental properties, will have the form:

$$P_T = S_{Ut} \cdot U_T + S_{AT} \cdot A_T + S_{WT} \cdot W_T + S_{CT} \cdot C_T + S_{ET} \cdot E_T, \quad (2)$$

where U_T, A_T, $W_П$, C_T, E_T – generalized indicators in accordance with technological universality, productivity, agrotechnical properties, cost of performing technological operations, environmental properties;

S_U, S_A, S_W, S_C, S_E - coefficients of weighting of corresponding generalized indicators of technological properties of a mobile power tool.

The structure of the index of environmental properties of E_T depends on the assignment of the estimated energy source and the purpose of the problem to be solved. In our opinion, with a comparative assessment of energy resources as a unit one can adopt the following indicators of their environmental properties: K_{qeg} - quality of exhaust gases; K_{pol} - pollution by operating liquids; K_{mds} - mechanical destruction of soil; K_n - Noise; K_v - vibration; K_{cs} - compaction of soil; K_{so} - is a lay-out scheme of an overburden. Then for the mobile power tool the index of ecological properties of E_T in the generalized form can be expressed in the sum of the products of the coefficients of weighting Si of individual generalized indicators on their relative values:

$$E_T = S_{Kqeg} \cdot K_{qeg} + S_{Kpol} \cdot K_{pol} + S_{Kmds} \cdot K_{mds} + S_{Kn} \cdot K_n + S_{Kv} \cdot K_v + S_{Kcs} \cdot K_{cs\,г} + S_{Kso} \cdot K_{so}, \quad (3)$$

where S_{Kqeg}, S_{Kpol}, S_{Kmds}, S_{Kn}, S_{Kv}, S_{Kso} - coefficients of importance of individual relative indicators of ecological properties.

Summarized unit values according to the equation (3) are not related to each other or to E_T with any analytic or empirical dependence. The task is to find such an addiction. The most appropriate method for solving this problem is the method of ranking individual indicators by interviewing experts [1, 7].

3. Results and discussion

The reliability of the results of the expert survey to determine the rank of individual indicators is determined with two main factors: the qualifications and the number of experts. Reducing the number of experts leads to a decrease in the accuracy of the result, as the assessment of each group is excessive by the assessment of each of the experts. With a very large number of experts, it becomes more difficult to identify their agreed opinion because of the diminution of the role of those judgments, which, although they differ from the majority of opinions, but far from always turn out to be false. In [1], the authors believe that such group should consist of at least 7 experts.

In our case, 10 experts were selected for the ranking of ecological and technological properties - scientists and specialists in the field of mechanization of agriculture, agronomy, ecology and environment (tables 1 and 2). As a result of their survey on the significance of individual indicators of the environmental and technological properties of the mobile power tool (tables 1 and 2), the ranks of the indicators themselves were determined. Moreover, the highest rank corresponds to the indicators of the highest significance, the lowest, respectively, - the least significant.

Table 1 *- Results of expert polls on the significance of individual indicators of the environmental properties of a mobile energy means*

Experts	composition of exhaust gases	contamination of operational fluids	mechanical destruction of soil	Noise	Vibration	compaction of soil	tractor layout diagram
	K_{qeg}	K_{pol}	K_{mds}	K_n	K_v	K_{cs}	K_{so}
	n1	n2	n3	n4	n5	n6	n7
Pastukhov V.I., Prof.	4	3	1	6	5	2	7
Didur V.A., Prof.	2	3	4	5	6	1	7
Nadykto V.T., Prof.	3	4	1	5	6	2	7
Petrukh V.G., Prof.	4	5	2	6	7	1	3
Uleksin V.O., PhD	7	5	1	4	3	2	6
Kuvachov V.P., PhD	3	4	1	5	6	2	7
Fediushko M.P., PhD	2	3	4	5	6	1	7
Bogatyrova O.B., PhD	3	4	2	5	6	1	7
Shkarivskyi G.V., PhD	5	6	1	4	3	2	7
Petrukh R.V., PhD	4	7	1	6	5	2	3
sum of ranks *T*	37	44	18	51	53	16	61
total ranks of single indicators t_k	3	4	2	5	6	1	7
deviation from the average amount of ranks	9	16	-10	23	25	-12	33
square deviations	81	256	100	529	625	144	1089
Sum of squares deviations R	2824						

Table 2 *- Results of expert polls on the significance of individual indicators of technological properties of a mobile energy product*

Experts	technological universality indicator	productivity indicator	agrotechnical properties indicator	the cost of the technological process	environmental indicator
	U_T	W_T	A_T	C_T	E_T
	n1	n2	n3	n4	n5
Pastukhov V.I., Prof.	1	3	2	4	5
Didur V.A., Prof.	4	2	1	3	5
Nadykto V.T., Prof.	1	3	2	5	4
Petrukh V.G., Prof.	2	1	5	3	4
Uleksin V.O., PhD	5	4	1	3	2
Kuvachov V.P., PhD	1	3	4	5	2
Fediushko M.P., PhD	3	4	2	5	1
Bogatyrova O.B., PhD	3	2	5	4	1
Shkarivskyi G.V., PhD	4	5	2	3	1
Petrukh R.V., PhD	3	1	4	2	5
sum of ranks *T*	27	28	28	37	30
total ranks of single indicators t_k	1	3	2	5	4
deviation from the average amount of ranks	-1	0	0	9	2
square deviations	1	0	0	81	4
Sum of squares deviations R	86				

The assessment of the consistency of the estimates obtained from experts was carried out using the coefficient of concordation W [1].

The verification of the significance of the coefficient of concordation W was carried out using the χ2-Pearson criterion [1].

According to the results of the expert survey (see Tab. 1 and 2), the weighting coefficients of the individual indicators of ecological and technological properties for mobile energy products were determined according to the equation [1]:

$$S_i = \frac{1 - \frac{t_k - 1}{n}}{\sum_1^n (1 - \frac{t_k - 1}{n})} \quad (4)$$

where $t_к$ - the final rank of a single indicator of ecological and technological properties;

n - total number of individual indicators.

Tab. 1 indicates that the generalized indicator of the environmental properties of a mobile energy facility is most strongly influenced by the K_{cs} soil compaction index, then the mechanical destruction of the soil K_{mds}, the composition of the exhaust gases K_{qeg}, the pollution of the operating liquids, the K_{pol} noise K_n, the vibration of the K_v and the smallest effect - the layout scheme of the energy K_{so}. Analysis of these indicators allows us to determine which structural-technological or regime parameters of the energy resource and to what extent affect the generalized index of its environmental properties. And the more deeply this analysis will be, the most accurate and successful will be proposed constructive-technological or regime measures to improve them.

The indicator of the environmental properties of a mobile power tool by the formula (3) as a result of a survey of experts (Tab. 1) will take the form:

$$E_T = 0{,}25\ K_{cs} + 0{,}22\ K_{mds} + 0{,}18\ K_{qeg} + 0{,}14\ K_{pol} + 0{,}11\ K_n + 0{,}07\ K_v + 0{,}03\ K_{so}.$$

According to experts, the greatest importance is the index of technological universality of U_T, then the agrotechnical properties of A_T, the productivity of W_T, the environmental integrity of the E_T and the smallest impact is the cost index of the technological process C_T. And the equation for calculating the technological level of the mobile power tool by the formula (1) as a result of the expert survey (Tab. 2) will take the form:

$$P_т = 0{,}33U_T + 0{,}27A_T + 0{,}2W_T + 0{,}13E_T + 0{,}07\ C_T.$$

The obtained result shows that today it is more relevant to assess the technogenic impact of a mobile energy facility on the environment than the cost of its implementation unit of work. And with this conclusion, one can not disagree, since the neglect of the impact on the environment in the near future can nullify the economic profit from the production of agricultural products. Therefore, estimation of the technological properties of a mobile power tool according to the criteria of its technological universality, productivity, agrotechnical quality, environmental properties and the cost of the performed operation allows us to make the most objective decision as to the feasibility of introducing it into production, the efficiency of its use and the technological level of any technological process.

4. Conclusions

1. The actuality and significance of the influence of the environmental properties of mobile energy on its technological properties is confirmed by a psychological experiment through a survey of experts. It is established that the value of this property, according to experts, is less than technological universality, productivity, agrotechnical quality, but higher than the cost of the performed operation. Taking into account the index of the environmental properties of a mobile power tool allows us to make the most objective decision as to the feasibility of introducing it into production, the efficiency of its use and the technological level of any technological process.

2. The evaluation of the importance of individual indicators for a generalized indicator of the ecological properties of a mobile power tool, according to the results of a survey of experts, showed that the most impact is the index of soil consolidation, then mechanical destruction of soil, composition of exhaust gases, pollution of operating fluids, noise, vibration and least impact is a layout diagram of the power tool. The analysis of these indicators allows us to determine which structural-technological or regime parameters of the energy source and to what extent influence the general indicator of its environmental properties. And the more deeply this analysis will be, the most accurate and successful will be proposed constructive-technological or regime measures to improve them.

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