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ANALYSIS OF RESULTS OBTAINED FROM SINGLE-FACTOR AND MULTI-FACTOR EXPERIMENTAL STUDIES ON WEAR TESTING OF CHISEL-CULTIVATOR PLOWSHARES

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АНАЛИЗ РЕЗУЛЬТАТОВ ОДНО И МНОГОФАКТОРНЫХ ЭКСПЕРИМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ ПРИ ИСПЫТАНИИ ЛЕМЕХОВ ЧИЗЕЛЬ-КУЛЬТИВАТОРА НА ИЗНОСОСТОЙКОСТЬ

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Аннотация: В данной статье представлены результаты одно- и многофакторных экспериментальных исследований рабочих органов почвообрабатывающих машин. В качестве входных факторов были выбраны скорость трения, твердость материала и сила давления, а в качестве выходного фактора, зависящего от входных, - величина износа. Результаты влияния этих факторов представлены в статье в виде таблиц и графиков.

Annotation: This article presents the results of single- and multi-factor experimental studies on the working components of soil-cultivating machines. Friction velocity, material hardness, and pressure force were selected as input factors, while the wear magnitude, dependent on these input factors, was chosen as the output factor. The effects of these factors are presented in the article in the form of tables and graphs.

Ключевые слова: сельскохозяйственные детали, плужных лемехов, износ, скорость трения, сила давления, твердость.

Keywords: agricultural parts, ploughshares, wear, friction speed, pressure force, hardness..

Introduction. On a global scale, including in Uzbekistan, the lifespan of working components supplied for soil-cultivating machines is significantly lower than the norms established by technical requirements, leading to their more rapid wear and deterioration. For example, in our republic, more than 250,000 plowshares become unusable annually. This number is increasing year by year because these plowshares are manufactured without the necessary design parameters, using unsuitable materials, and without adhering to proper production technology and heat treatment procedures. As a result, our republic spends more than 1250 tons of rolled metal, or in other words, nearly 4 billion soums, on plowshares alone. High-performance and powerful equipment is used in the world in the field of agriculture. As a result, the yield of cultivated crops increases, and manual labor and the cost of production are reduced. These measures play an important role in providing the population with food products. One of the features of the use of agricultural machinery is their direct contact with the soil. As a result, the working bodies of these machines wear out quickly due to friction with the soil and become unusable. As a result, one-third of the energy produced worldwide is spent on overcoming friction, and one-fourth of the annual metal production is spent on restoring the part lost due to wear in machine parts and joints. Therefore, today, when fuel and material reserves are decreasing in the world, and the requirements for the reliability and durability of machines are increasing, reducing these costs and the efficient use of existing agricultural machinery are considered important tasks [1].

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Research methodology. We conducted our research on the factors influencing the wear of plowshares, which are one of the main wear-resistant working bodies in agriculture, in order to increase their service life.
To verify the obtained results, one-factor experimental studies were conducted under laboratory conditions.
In the experiments, the dependence of the amount of wear on the force of pressure, the hardness of the material, and the speed of the unit was studied. At the first stage, the dependence of the amount of wear on the pressure force acting on the sample was studied. The experiments were conducted at a speed of m/sec.
In the second stage of the experiments, the dependence of the amount of wear on the hardness of the tested materials was studied. In this case, the hardness of each tested sample was selected, the hardness of the uncured steel grade ШХ15СГ was 29 HRC, and the hardness of the steel grade 45Г was 56 HRC. In order to ensure reliability, test experiments were conducted under a pressure force F=30N and F=150N. At the next stage of the experiments, the dependence of the amount of wear on the speed of friction of the samples was studied. For experimental tests, three different speeds were determined: ϑ =0.314 m/s, ϑ =0.418 m/s, ϑ =0.523 m/s. To ensure reliability, test experiments were conducted under pressure forces F=35N and F=175N.
The obtained results and discussions. The results obtained on the study of the dependence of the amount of wear on the force of pressure are as follows (Table 1).
Table 1

№	Indicator name	Load on the sample chisel-cultivator share, N				
		30	60	90	120	150
ϑ=0,314 *m/s*						
1	Wear amount, g	0,2	0,42	0,61	0,84	0,92
ϑ=0,523 *m/s*						
2	Wear amount, g	0,25	0,48	0,68	0,91	1,03

Analysis of the results obtained in the experiments showed that with an increase in the load acting on the blades, their wear increases (Fig. 1).

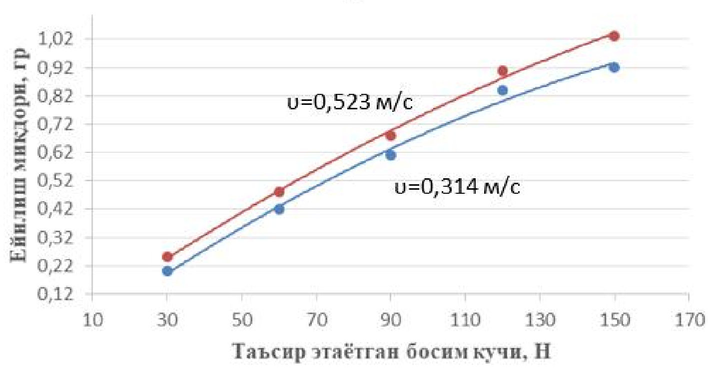

Figure 1. Graph of the dependence of wear on load

Based on the obtained results, the graphs of the change in the amount of wear of the share samples depending on the pressure force applied to them can be represented by the following empirical formula.
a) at a friction velocity ϑ =0.314 m/s
$\varepsilon = -0{,}00002F^2 + 0{,}0096F - 0{,}08$, g. $R^2 = 0{,}993$

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б)) at a friction velocity $\vartheta=0{,}523$ м/с when
$\varepsilon=-0{,}00002F^2+0{,}0093F-0{,}022$, g. $R^2 = 0{,}997$
In the second stage of the experiments, the dependence of the amount of wear on the hardness of the material of the tested share samples was studied.

In this case, the hardness of each tested sample was measured, and the amount of wear was studied. The results of the experiments are presented in Table 2.

Table 2

The amount of wear depending on the hardness of the sample material

№	Indicator name	Hardness of the chisel-cultivator share sample, HRC						
		29	**38**	**45**	**52**	**53**	**56**	**58**
				$F=30\ N$				
1	Wear amount, g	0,36	0,7	0,35	0,28	0,25	0,2	0,08
				$F=150\ N$				
2	Wear amount, g	3,05	3,03	1,32	1,16	1,03	0,92	0,61

In the studies, it was established that the amount of wear decreases with an increase in the hardness of the sample material (Fig. 2). With a doubling of the hardness, the amount of wear decreased from 0.36 g to 0.08 g.

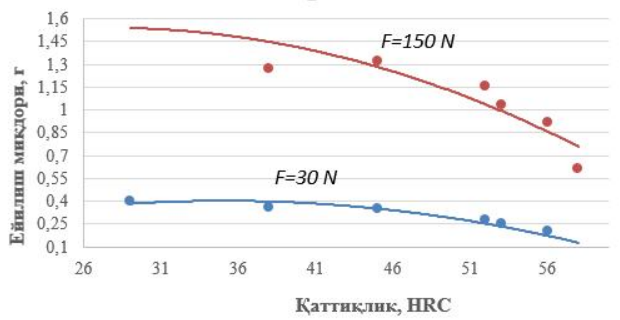

Figure 2. Graph of the dependence of wear on the hardness of the material
Based on the obtained results, the graphs of the change in the amount of wear of the share samples depending on the sample material can be represented by the following empirical formula.
a) $F=30\ N$ When
$\varepsilon=-0{,}0005H^2+0{,}0368H-0{,}2425$, g. $R^2 = 0{,}9218$
b) when the applied load is F=150N
$\varepsilon=-0{,}0008H^2+0{,}0463H+0{,}903$, g. $R^2 = 0{,}868$
In the studies, the dependence of the amount of wear on the speed of friction of the samples was studied. The obtained results are presented in Table 3.
Table 3
The amount of wear depending on the speed of friction of the samples

№	Indicator name	Friction rate of the chisel-cultivator share sample, m/s.		
		0,314	**0,418**	**0,523**

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		F=30 N		
1	Wear amount, g	0,14	0,16	0,17
		F=150 N		
2	Wear amount, g	0,28	0,30	0,31

Studies on the study of the influence of the friction rate on the amount of wear showed that with an increase in the friction rate, wear increased significantly (Fig. 3). For example, if the amount of wear of the sample was equal to 0.14 g at a speed of friction θ=0.314 m/s, then it was equal to 0.17 g at a speed of friction θ=0.523 m/s.

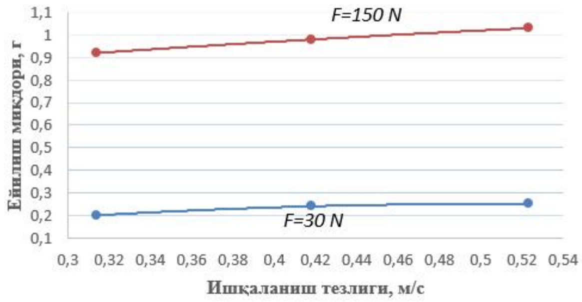

Figure 3. Graph of the dependence of the amount of wear on the speed of friction

Based on the obtained results, the graphs of the change in the amount of wear of the share samples depending on the friction rate can be represented by the following empirical formula.

a) when the applied load is F=30 N

$\varepsilon = -1{,}3846\vartheta^2 + 1{,}39816\vartheta + 0{,}6756$, g. $R^2 = 1$

b) at a load F=150 N

$\varepsilon = -0{,}482\vartheta^2 + 0{,}9297\vartheta + 0{,}826$, g. $R^2 = 1$

The dependence of material hardness, pressure force, and friction speed on the amount of wear of chisel-cultivator blades was studied through multifactorial experiments. When studying the influence of factors on the evaluation criteria, it was assumed that the first-degree polynomial corresponds, and the research was conducted according to the plan of a full-factor experiment. Simple single-factor experiments showed that wear decreases with increasing material hardness, and wear increases with increasing pressure force and friction speed applied to the sample [2]. In subsequent experiments, multifactorial experiments were conducted to determine the combined effect of these indicators on wear. When conducting experimental studies, the amount of wear of plowshares was taken as the output factor, the hardness of the chisel-cultivator blade material, the speed of friction of the samples in the abrasive medium, and the pressure force acting on it were taken as the input factors influencing the output factor. They are denoted by the following conventional symbols: X1 - hardness of the chisel-cultivator share material; X2 - pressure force; X3 - speed of friction. The levels of factors and the range of variation (change) were determined (Table 4).

Table 4

Factor designations, levels, and variation intervals

Factor naming	**Unit of measure ment**	**Factor designat ion**	**Range of variation**	**Factor levels**		
				lower (–1)	**basisй (0)**	**High (+1)**
Pressure	N/sm^2	X_1	60	30	90	150
Hardness of chisel-cultivator share material	HRC	X_2	14	35	45	56

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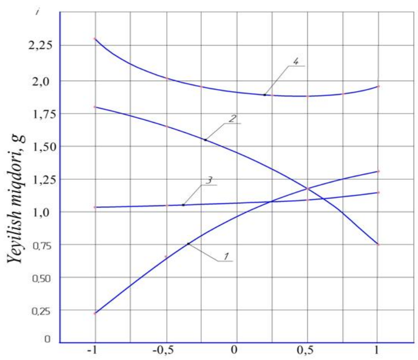
Friction rate	м/с	X_3	0,105	0,314	0,418	0,523

The data obtained from the experiments were processed using the "Statistica" software for processing and analyzing experimental and statistical data.

In this process, the Cochran criterion was used to assess the homogeneity of variance, Fisher's F-test was employed to evaluate the adequacy of regression analyses, and Student's t-test was utilized to assess the significance of the regression equation coefficients. As a result, the following polynomial was obtained.

$Y=1.17875+0.86875X_1-0.55125X_2+0.04625X_3-0.48125X_1X_2+0.01625X_1X_3+0.02125X_2X_3+0.001$

To further clarify the results of the obtained regression equations, graphs of the dependence of the equation factors were obtained.



1 - influence of pressure force; 2 - influence of hardness; 3 - influence of friction speed; 4 - the total effect of all three factors;
Figure 4. Graph of the influence of factors on the amount of wear of samples

Conclusion. The results of the conducted multifactorial experiments demonstrate that the optimal values of the combined influence of these input factors, which ensure minimal wear, are around 0.5 on the graph. The corresponding values of the input factors at this 0.5 point are 120 N for pressure, 50 HRC for hardness, and 0.470 m/s for friction speed. From the graph in Figure 4, we can observe that among the input factors, hardness has the highest impact on wear.

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