ASSESSMENT OF THE RELATIONSHIP BETWEEN DIMENSIONS IN THE WEAR OF THE SPIKE-SHAPED CLAW.

Yusufaliyev Abduraxmon Tilavovich
Gulistan State University
https://doi.org/10.5281/zenodo.17874583

The study presents the results of determining the interrelationship between the wear of the arrow-shaped claw tip length and the wing width, as well as the changes in their self-sharpening angles. It was found that the first relationship is linear, while the second one has a nonlinear (curvilinear) character. In order to ensure equal service life for both the tip and the wings of the existing arrow-shaped claw, it was determined that the metal reserve or wear resistance of the tip must be increased by a factor of 2.91.

State of the Problem

It is known that cultivator arrow-shaped sweep shares (CASS) undergo abrasive wear during operation [1,2,3]. First of all, its tip, which penetrates the soil, encounters high resistance and wears out at an intensive rate (1.2–1.6 mm/ha) [4]. The design shape of the CASS tip determines its wear resistance and
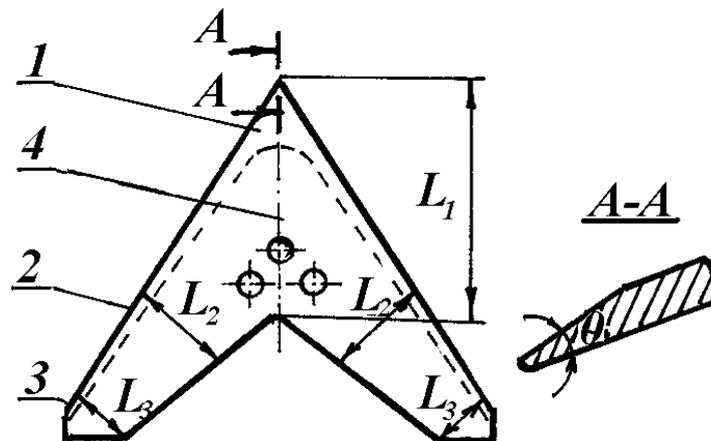
Figure 1. Diagram of the CASS: 1 — tip, 2 — wing, 3 — tail, 4 — axis.

It has been established that the shape of wing wear significantly affects its wear rate [5,6]. However, the issues related to how dimensional changes of the tip during abrasive wear influence the dimensional changes of the wings have been studied very little. To clarify this matter, special investigations were conducted, and their results are presented below:

Relationship Between the Length of the CASS Tip and the Wear in Wing Width

It is known that as the CASS tip wears, its dimensions decrease along the axis—meaning its initial (nominal) size changes—and the curvature radius of the tip increases (Figure 1). The results of studying the relationship between changes in the tip length and the wear in the middle and tail-section wing widths are presented in Figure 2.
The regression equations of the relationship have the following form:

$$L_2 = 0{,}344\,L_1 - 0{,}997$$

$$L_3 = 0{,}21L_1 + 0{,}73$$

As can be seen from the diagrams, a 1 mm decrease in the CASS tip length due to wear corresponds to 0.344 mm of wear in the middle part of the wing and 0.21 mm of wear in the tail part. Wear of the sweep tip is 2.91 times greater than the wear of the wing's middle part, and 4.76 times greater than the wear of the tail part. The wear in the middle part of the wing is 1.63 times higher than that of the tail part.

Based on the values of the determination coefficient, it can be stated that 100% of the variation in the wear of the wing's middle part ( ) and 94% of the variation in the wear of the tail part ( ) are explained by changes resulting from wear of the sweep tip. Only in the latter case do the remaining 6% of variations result from other factors.

The characteristics of this relationship are presented in Table 1.
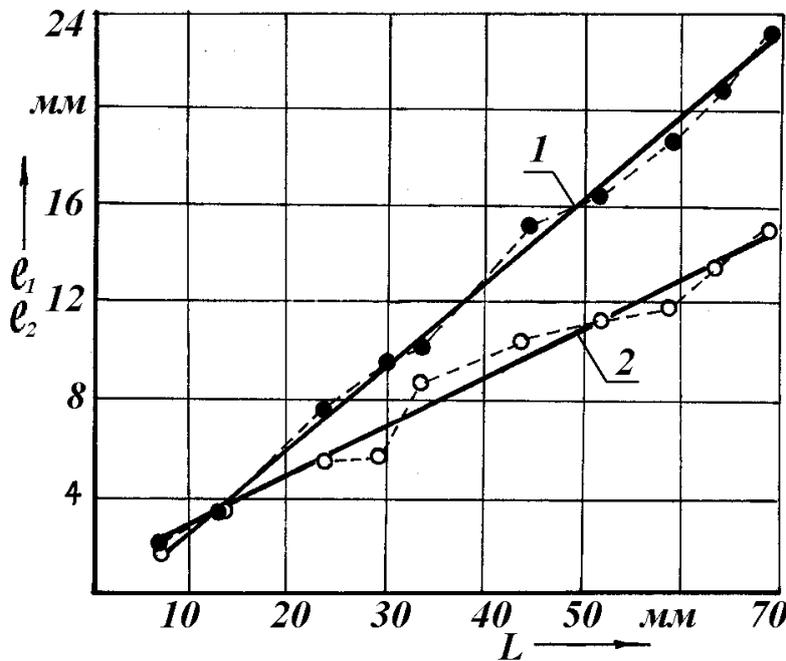

Figure 2. Theoretical regression lines and scatter plots showing the linear correlation between the wear of the CASS tip length and the wear of the wing width.

**Table 1. Evaluation of Correlation Relationships**

T/p	Interrelationship Parameters	Notation	Relationships	
			$l_1 = f(L)$	$l_2 = f(L)$
1.	Correlation coefficient	r	1,00	0,97
2.	Determination coefficient	d	1,00	0,94
3.	Regression coefficient	b	0,344	0,21
4.	Standard error of the correlation coefficient	σ_r	0	0,087

5.	Standard error of the regression coefficient	σ_b	0	0,019

When performing analysis of variance for the values of and (Table 1), the results indicate that deviations from linearity occur due to random variation in the sample, and the null hypothesis—that and are not linearly related—is rejected.

Relationship Between the Length of the CASS Tip, Wear of the Wing Width, and the Sharpening Angles

When the CASS wears in the soil, it remains sharp, which indicates that it possesses self-sharpening properties. The metal allocated for the tip and wings ensures that the tool meets the required agrotechnical standards throughout the wear process. To determine this, the relationships between the wear of the tip and wings and the changes in the sharpening angles were studied. The results are presented in Figures 3 and 4, and Table 2.
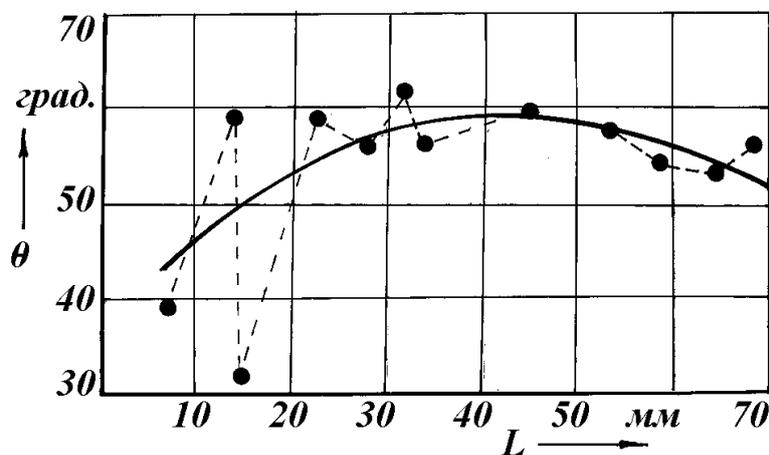
Figure 3. Graph of the relationship between the CASS tip length and the sharpening angles.

Based on the presented experimental results, it can be stated that the relationship between the CASS tip length, the wear of the middle and tail parts of the wing, and the change in sharpening angles is very weak. That is, a 1 mm wear of the tip corresponds to a 91 (0.150) change in the sharpening angle, while the middle and tail parts of the wing correspond to $(3.1)_1$ (0.050) and $(1.7)_1$ (0.030), respectively.

According to the determination coefficient, it can be concluded that 20% of the change in the tip sharpening angle is associated with wear along its length, while in the middle and tail parts of the wing, only 0.36% and 0.09% of the change is associated with wear in width, respectively. To test the hypothesis of a linear relationship between angle changes and wear, analysis of variance (ANOVA) was performed for the changes in sharpening angles (θ, θ_1, θ_2) (Table 2). The results show that in both cases, . Therefore, the linear relationship is not due to random sample variation, and the null hypothesis of the absence of such a relationship cannot be rejected.
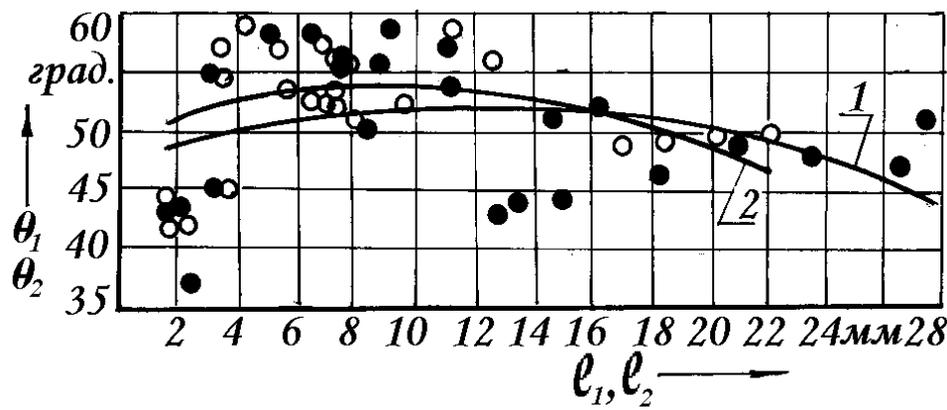
Figure 4. Graph of the relationship between the wear of the wing and tail widths of the CASS and the corresponding changes in sharpening angles.

These relationships are nonlinear, as shown by the initial increase in angles followed by a subsequent decrease as wear progresses (Figures 3 and 4). It was determined that these nonlinear relationships can be described using the following theoretical regression lines.

$$\theta = 36{,}36 + 1{,}052\,L - 0{,}012\,L^2$$

$$\theta_1 = 49{,}114 + 0{,}455\,l_1 - 0{,}022\,l_1^2$$

$$\theta_2 = 50{,}911 + 0{,}627\,l_2 - 0{,}0368\,l_2^2$$

General Conclusions

Based on the analysis of the experimental results, the following points can be emphasized:

The wear of the CASS tip and wings exhibits a linear relationship, and their technical service lives are unequal. Due to differences in wear intensity, the metal reserve allocated for the tip should be 2.91 times greater than the current value, or its wear resistance should be increased accordingly.

There is no linear relationship between the linear wear of the CASS and the sharpening angles of the tip.

In improving existing cultivator arrow-shaped sweeps and designing new constructions, instead of using highly wear-resistant and expensive materials, it is possible to significantly extend their service life by accounting for the observed correlation between tip and wing wear.

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