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Experimental Study of Chisel Tool Elastic Shank Operation

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Abstract: The article presents results obtained after the experimental studies of elastic and rigid shank of chisel tool. The studies investigated the influence of soil degradation by a moving working body on occurrence of oscillations from elastic shank as compared to a rigid shank. Also various ways of metering registered values (traction resistance, frequency of oscillations) in order to determine the most optimal options have been considered and evaluated. For measuring energy characteristics, strain-measuring units and resistive-strain sensors located directly on the elastic shanks were used and for measuring vibration characteristics, inertia accelerometer was used. Calibration was performed on strain-measuring units and strain gages glued onto elastic shank, testing was performed with recording energy and vibration indicators of chisel tool elastic shank with a range of working bodies compared to a rigid shank. Results of experiments were recorded onto oscillographic tape. Areas of stable recording of work process were detected visually. Due to the limited pass length, records were processed using centerline method in order to define value of traction resistance and using flexing method in order to define process alternating frequency.

Key words: Chisel Tool · Elastic Shank · Strain-measuring Units

INTRODUCTION

Research of the processes of chisel plow soil cultivation has been caused by seeking ways for improving productivity; reduction of fuel consumption; elimination of unwanted consequences of soil compaction by heavy modern tractors, agricultural machinery and other transportation equipment; improving agrophysical soil properties, preservation and accumulation of fertility and ultimately increasing productivity of agricultural plants [1].

The issue of creating and improving chisel tools for deep tillage technology and studying effectiveness of their use in crop growing is one of the main research objectives.

In Kazakhstan, as in most countries of the world, during soil treatment, phenomena occur that adversely affect soil fertility [2]:

- Due to frequent passage of heavy tractors and agricultural machinery, intense destruction of soil structure and excessive soil compaction occurs [3, 4];
- Long-term use of traditional moldboard plowing reduces crop yields;
- Due to adverse climatic conditions, wind and water erosion develops;
- Primary soil cultivation with conventional moldboard plows is a very energy-intensive, inefficient operation that requires huge labor costs, time and significant fuel costs [5, 6].

In order to reduce these effects on soil, it is necessary to improve the processes of soil cultivation, improve tillage tools and actively introduce advanced soil protecting and energy-saving technologies [7, 8].

In solving the complex issues of improving technology, we consider it necessary to pay attention to reduction of soil compaction [9, 10].

Purpose and Procedure: The work has been done at the Machinery Use Scientific Department of the Kazakh National Agrarian University together with the Research Institute of Mechanization in Gödöllõ, Hungarian Republic.

The aim of the research was to obtain data about chisel tool elastic shank performance, as well to determine the most efficient methods of measuring values registered.

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Fig. 1: Chisel point

Fig. 2: A blade

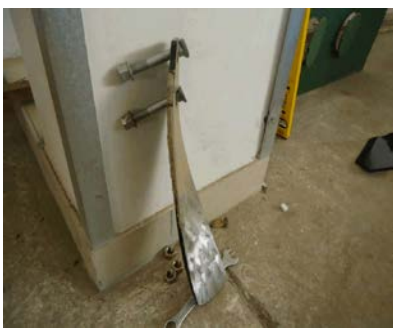

Fig. 3: Moldboard chisel point

The studies investigated the influence of soil degradation by a moving working body on occurrence of oscillations from elastic shank as compared to a rigid shank. In order to ensure purity of results, the research was conducted in a soil box, which makes it possible to ensure the most homogeneous aggregate composition of soil and prevent accidental factors. Also various ways of metering registered values (tractive resistance, frequency of oscillations) in order to determine the most optimal options have been considered and evaluated.

Objects of Research:

- Bederstad elastic shank;
- Rigid shank;
- Set of work tools: chisel point, A blade, moldboard chisel point (Fig. 1, 2, 3).

For measuring energy characteristics, strain-measuring units and resistive-strain sensors located directly on the elastic shanks were used and for measuring vibration characteristics, inertia accelerometer was used.

The Procedure Included the Following:

- Preparing strain units and elastic shank for testing.
- Preparation of laboratory unit and soil.
- Calibration of strain units and strain gages glued onto elastic shank.
- Testing with recording energy and vibration indicators of elastic shank with various work tools compared to rigid shank.
- Processing test results.

Procedure

Preparation for Test: Preparation included the preparation of the shank being tested, preparation of strain-measuring equipment, installation and checking electrical circuits. Strain gages are glued on in three points of a rigid shank.

ПКБ-15-200 wire strain gages with 20 mm base were used. Gluing spots should be cleaned and degreased with acetone and alcohol.

Gages are glued using cyanoacrylat or butvar-phenolic adhesive. Gluing was made exactly according to markup with simultaneous gluing of mounting pad.

After drying (2-3 days) strain gages pins and installation drives were soldered, followed by insulation against moisture and mechanical damage with epoxy resin and wrapping tape.

Resistors are glued onto strain units in a similar manner. For gluing, resistors with 5 or 10 mm base were used.

Signals measured were amplified and recorded by Topaz-3 strain-measuring amplifier and H-700 oscilloscope.

Strain Measurement Scheme:

- Resistive-strain sensors - Topaz-3 amplifier - H-700 oscilloscope.

Accelerations were recorded by a conventional accelerometer connected to a strain amplifier.

Preparation of Laboratory Unit: Preparation included setting depth wheels to required depth and checking and tightening assembly fixtures of chisel equipment.

Soil preparation consisted of several alternating steps: leveling with a visipanel, intensive tillage with cultivator teeth (5-6 passes), sprinkling. The ultimate goal of soil preparation was to achieve soil uniform aggregate composition over the entire length of the pass.

Calibration of Strain Units and Strain Gages Glued onto the Shank: Calibration was performed on a load bank and loading results were recorded onto oscillographic tape. Strain-gage units were calibrated in horizontal and vertical position using the following method:

- After strain-gage unit is installed on the load bank, it is loaded with force equal to 5 kN (force indicated by a dynamometer), after that the unit was unloaded to zero;
- Fastening bolts are tightened;
- After that, checkout calibration is made, load is varied from 0 to 3.5 kN in longitudinal direction and from 0 to 2 kN in vertical direction each 0.25 kN. Upon reaching maximum load, units are unloaded in reverse order. For each loading value, power supply voltage was recorded. The procedure is to be repeated three times. Calibration of resistive-strain sensors glued onto the shank was made in longitudinal direction in the same manner.

Making Experiments in Soil Box: Elastic and rigid stand shanks were installed on a breadboard setup at 1 m distance to avoid interference. Before test pass, a check pass was made in order to set elastic shank and rigid shank to the same tillage depth.

Methods of Processing Experimental Data: Results of experiments were recorded onto oscillographic tape. Areas of stable recording of work process were detected visually. Due to limited pass length, records were processed using centerline method in order to define value of traction resistance and using flexing method in order to define process alternating frequency.

Results of the Research: Length of work pass was equal to 22 m. Three segments were allocated with soil humidity: W = 5-13%, W = 13-15% and W = 15-17%.

After the pass, depth of tillage with an elastic shank and a rigid shank was recorded. Measurements were made after each 1-1.5 m.

Measurement results are summarized in Table 1. For elastic shank, value of vertical component of traction resistance Rz was not shown, as it had a very little significance, as well as the value of fz fluctuation frequency for rigid shank was not shown.

Analysis of the results shown makes it possible to make the following conclusions:

- Frequency of variation in the horizontal component of soil resistance is the same value for the elastic and rigid shanks and is equal to fk = 2.5-3 Hz.
- Recurrence of variations in horizontal component for elastic shank is manifested better than for a rigid shank.
- Frequency of variation in the vertical component Rz for elastic shank is fz = 9.5-12.5 Hz.
- In heavy duty work modes (high traction resistance) direct relationship between peaks of the envelope curve of accelerometer readings and Rz fluctuations peaks was noted. In case of low loads, such relationship was not clearly seen.
- Rz fluctuations in elastic rack took positive and negative values with the same amplitude (amplitude of changes in a moldboard chisel point Rz = 75 kg). For A blade, average value of Rz, relative to which oscillation was made was equal to 50-80 kg.

The second phase of the research included obtaining energy characteristics (horizontal component of soil resistance) by different methods and defining influence of a strain-measuring units on elastic shank characteristics. Compared were two variants of elastic shank installation (with or without strain-gage unit) with moldboard chisel point.

During comparative tests the following characteristics were taken:

- Static longitudinal characteristics;
- Dynamic (natural vibration frequency measured) characteristics;
- Energy performance characteristics.

Data on static longitudinal loading is shown in Table 2. Values of coefficients C11 and C12 were calculated by the following formula:

$$C_{i,j} = \frac{S_j}{P_i}$$

Analysis of oscillograms with recording of free oscillations shows that strain-gage unit generates its own oscillations (120 Hz) on top of oscillations of elastic

Table 1: Energy and vibration indicators of elastic and rigid shank with various work tools

Work conditions	Work indicators: Elastic shank				Rigid shank			
	Rκcp, kN	$f_{\hat{e}}$, Hz	f_z, Hz	A, 9.8 m/c2	f,Hz	*Rκcp, kN*	$f_{\hat{e}}$, Hz	*Rzcp, kN*
	Chisel point							
W=5-13% V=2.8 m/s	1.1	3	12	1…5	-	0.85	3	0.2
W=16-17% V=2.8 m/s	3.5	3	12.5	1…4	12.5	2.8	-	0.3
	Moldboard chisel point							
W=5-13% V=2.7 m/s	1.86	3	12	2…3	-	1.54	2.9	0.3
W=13-15% V=2.7 m/s	3.95	2.9	11	1…2	-	3.65	2.9	0.35
W=16-17% V=2.7 m/s	3.8	2.9	10	1…3	10	3.9	2.5	0.5
	A blade							
W=5-13% V=2.7 m/s	1.25	-	11	1…6	-	0.85	-	-
W=15-17% V=2.7 m/s	4.95	-	9.5	2…5	9.5	5	-	-

Table 2: Data on static and dynamic tests of elastic shanks with or without strain-gage units

	Indicators of static loading: Elastic shank with strain-gage unit					Elastic shank without strain-gage unit				
P, kN	S_k, mm	S_z, mm	C11, kN/m	C12, kN/m	f_0, Hz	S_k, mm	S_z, mm	C11, kN/m	C12, kN/m	f_0, Hz
0.5	33	20	15.1	25.4	7.0	32	11	15.6	45.5	10.0
1.0	65	42	15.6	22.7		62	25	18.5	35.7	
1.5	93	60	17.8	27.7		85	38	22.7	38.5	
2.0	115	76	22.7	31.3		110	52	20.0	35.7	
2.5	135	88	26.3	41.6		130	64	25.0	41.0	

Table 3: Energy performance of elastic shank with and without strain-gage unit at W = 5-13% and V = 2.8 m/s

	Work indicators: Elastic shank with strain-gage unit				Elastic shank without strain-gage unit		
Sum of measurement	*R1, kN*	*R2, kN*	*R4, kN*	*Rx, kN*	*R1, kN*	*R2, kN*	*R4, kN*
Sum	1.28	0.96	1.65	1.13	1.3	0.92	0.95
t_1	3.37	3.22	3.45	2.99	2.33	1.91	1.48
t_2	1.93	1.77	1.67	1.85	1.85	1.47	1.39
t_3	1.37	1.3	1.57	1.28	0.89	0.48	0.63
t_4	-	-	-	-	0.3	-0.17	-0.08

shank, which fact somehow distorts the overall picture at the beginning of transition process (about 20 oscillations).

Data on strain-gaging of Vederstad elastic shank along the elastic curve is shown in Table 3.

Load values were measured at the same moment in different points.

Analysis of oscillographic records and obtained data shows that:

- Arbitrary placement of strain gages on the shank in order to determine soil elastic resistance can lead to significant errors, since resistive-strain sensors signals under static loading do not correspond to the same under dynamic loading.
- During dynamometer test of elastic shank in soil box, signals from resistive-strain sensors differed from each other:

- In the case of an elastic strut with resistive-strain sensor, difference between R4 and R1 was 15%, between R1 an R3 was 100% (especially the difference is noticeable in case of sharp load growth),
- In case of an elastic shank without strain-gage unit, difference between R1 and R4 was 25%.
- Resistive-strain sensors recorded the entire spectrum of the oscillations, while it was known that Rx signal showed low-frequency vibrations and Rz - high-frequency vibrations.

Conclusions:

- Studies in soil box showed that the characteristics related to the variation of the horizontal component of soil traction resistance is the same for elastic and rigid shanks.
- When a working tool is being moved on elastic shank in soil, its low-frequency oscillations that correspond to soil traction resistance oscillations are topped by high-frequency oscillations corresponding to elastic shank's own oscillating frequency.
- When working in highly humid soil, the tool on elastic shank has unstable depth in soil.
- To assess traction resistance of the work tool on elastic shank by strain-gauge methods, one must take into account dynamic effects arising from shank oscillations.

CONCLUSION

Widespread use of chisel cultivators is stipulated by high efficiency of minimum soil tillage, ensuring soil protection from erosion, reduction of soil compaction and dusting, reduction of energy and labor costs and cash expenses.

Chisel cultivators are equipped with a wide range of work tools, including various types of points and A-blades. Points width varies from 35 to 100 mm and width of A-blades does not exceed 220-270 mm.

Working tools of chisel cultivators are mainly installed on elastic or spring-loaded shanks.

REFERENCES

1. Trufanov, V.V., 1999. Deep Soil Chisel Plowing. All-Union Academy of Agric. Sciences named after V.I. Lenin. Moscow: Agropromizdat, pp: 5-8.
2. Umbetaliev, N.A., 2008. Parameters of Chisel Cultivator Work Tools. From Zonal Conservation Cropping System to Adaptive-Landscape One. In the Proceedings of the International Scientific And Practical Conference Dedicated to 100 Anniversary of A.I. Barayev. Almaty: CopyLand, pp: 167-169.
3. Kuznetsov, S.V., 1974. About Negative Effect of Soil Compaction by Tractors and Agricultural Machinery. Works of All-Russian Research Institute of Agricultural Mechanization, 66: 21-23.
5. Evolution dans l'utilisation des Chisels en France, 1971. Trachtenes Mash. Agr., 47: 39-46.
6. Keller, K. and M. Flammer, 1977. Use of Cultivators in Agricultural Practices. Landtechnik, 32(10): 401-407.
7. Deep Tillage and Para Plowing Erodible, Compacted and Temporarily Waterlogged Soils. Recommendations, 1988. Eds., Turetsky, R.L., F.P. Tsyganov *et al*. Minsk Central Research Institute for Mechanization and Electrification of Agriculture in Non-Black Earth Area, pp: 31-32.
8. Kazakov, V.P., 1981. Heavy Soils Subsoiling. In Heavy Soils Dewatering. Ìoscow: Kolos, pp: 25-26.
9. Izvekov, V.P., 1991. Preventing Environmental Collapse. Arable Farming, 4: 17-19.
10. Guitard, D., 1973. Quelgues Materiels Emploes dans la Cylture sans Labour. Bull inf. Cent. Nat itud. Exp. Mash. Agr., 190: 33-59.
11. Soil Cultivation with the Application of Chisel Tools. In the Proceedings of the 9th International Scientific and Practical Conference «Strategiczne Pytania Swiatowej Nauki-2013», 27(rolnictwo weterynaria, przemysl nauka i studia), pp: 9-10.