THE SHARE-MOLDBOARD PARAMETERS OF SOME PLOUGH BODIES

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Abstract. The main parameters of the plough body that determine the ploughing efficiency are the initial and the final soil slice lifting angles on the share-mouldboard surface, the angle of its horizontal generatrix, the radius of this surface and the working width of the body. Studies have been carried out to determine the share-mouldboard parameters of some contemporary plough bodies: the cultural (digger), semi-helicoidal and helicoidal types. For this purpose profilograms of its share-mouldboard surfaces are made and the values of the investigated parameters measured. The energetic, agronomic and economic characteristics of ploughs were estimated by their testing. As the result of investigations, it was discovered that the optimal values of the main parameters of the bottoms for contemporary ploughs are: the inclination angle of the share towards the furrow bottom – 28…32˚; the inclination angle of the horizontal generatrix towards the furrow wall on the initial part of the share-mouldboard surface – 34…38˚, on the top - not less than 48˚ ; the working width of the bottom – 45…50 cm. The conducted investigations show that only those ploughs generally meet the requirements mentioned above which have bodies with gently sloping semi-helicoidal or helicoidal share-mouldboard surfaces, such as the Kverneland plough body No. 8. The use of bodies having optimal parameters allows attaining good ploughing quality, reducing the draft resistance by 12…20 % and raising correspondingly the efficiency, saving fuel and financial resources for ploughing.

Key words: plough body parameters, initial lifting angle, final lifting angle, angle of horizontal generatrix, optimal parameters.

Introduction

Ploughing is one of the most power-consuming and expensive processes in agricultural production. It is known that the draft resistance of ploughs, the energy requirement for ploughing, the quality of ploughing and expenses depend on the plough body design, which is determined by the share-mouldboard parameters and the parameters of its supporting surfaces, as well as such soil properties as its hardness, density, friction and adhesion.

In the Latvian agriculture the transition process from the old machines, made in the former Soviet Union (now – the Commonwealth of Independent States, CIS), to new ones coming from the West European countries is going on. The new machinery is more progressive but more complicate and expensive too. This may raise the costs of agricultural production. Therefore measures should be taken to choose and use more efficient machines, including ploughs. In the previous years the new machines, including the ploughs were tested at the Baltic Machine Testing Station (Baltic MTS) with the participation of the scientists from our institute, and were recommended or not recommended for the use in the Baltic States [1-4]. At present nobody carries out such an assessment of the ploughs in Latvia. The documents about their purchase do not present objective information allowing to choose the most suitable plough for particular circumstances.

The purpose of this investigation was to clarify the values of the main parameters of share-mouldboards surfaces of the plough bodies allowing the estimation of their efficiency and suitability for ploughing soil under Latvian conditions.

Materials and methods

An assessment of some plough bodies, mainly used on Latvian farms, as well as those offered by the plough manufacturers and dealers, was carried out (Fig. 1, 2). The design of the plough body and its share-mouldboard surface are defined by its angular and linear parameters (Fig. 3), the main of them being as follows.

The angular parameters of share-mouldboard surface:

- the initial inclination (lifting) angle - ε_1 (the inclination angle of the share towards the horizontal plane, respectively – towards the furrow bottom);
- the final lifting angle - ε_2 (the inclined upper part of the surface);

- the inclination angle of the horizontal generatrix - γ (the inclination angle of the horizontal shape lines towards the vertical-longitudinal plane, respectively – towards the furrow side) and the regularities of its variation).

The linear parameters of the share-mouldboard surface and the plough bottom:

- the working width of the bottom – b ;
- the working width of the plough share - b_s ;
- the radius of the mouldboard curvature – r ;
- the height of the share-mouldboard surface – h ;
- the length of the share-mouldboard surface – l_x (the length of the projection in the direction of its movement);
- the width of the share-mouldboard surface – b_y (the width of the body profile).

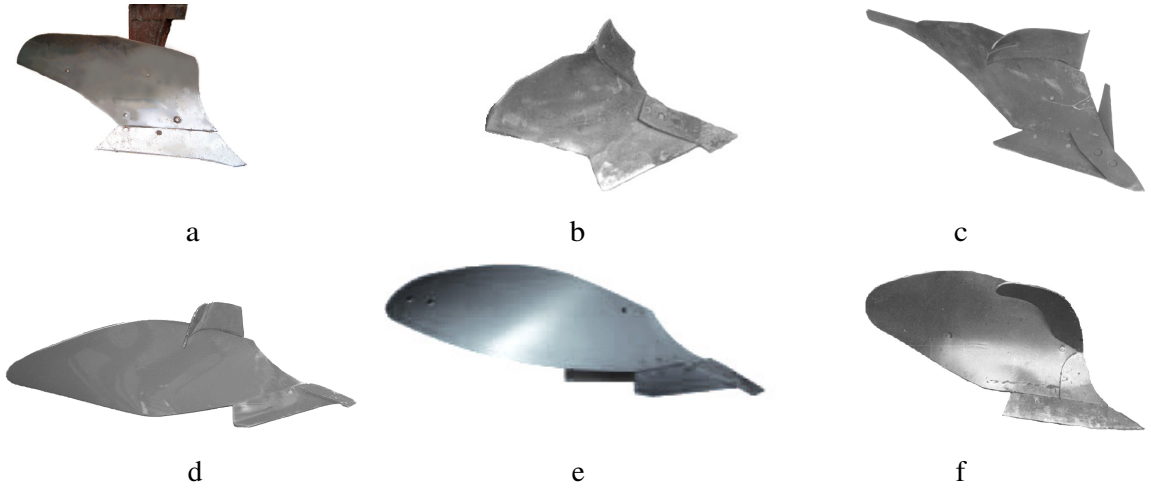

Fig. 1. **The types of the plough bodies:** a – cultural body PLŽ 31.000 of the PLN plough group; b – a culture-semi-helicoidal body PGC–61.000 (PGC–31.000) of the PGP plough group; c – a semi-helicoidal body KVU-40000 manufactured for the PGP plough group; d – a semi-helicoidal body No 8 of the Kverneland plough group; e – a helicoidal body SA 600 HL of the Overums-Bruk plough group; f – a culture body P 135-13 of the plough PN-1-422 from Czechy

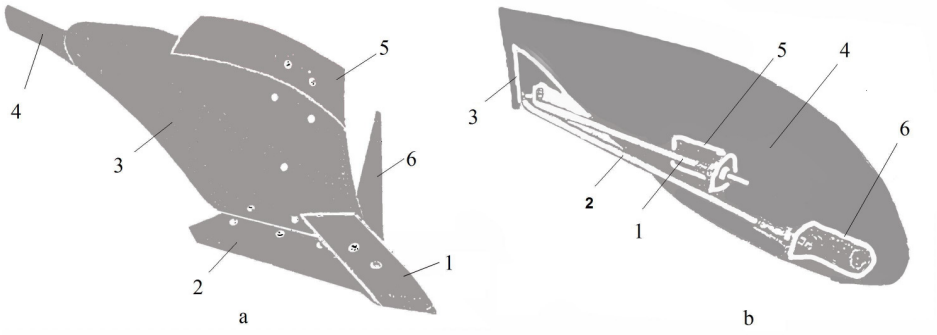

Fig. 2. **A semi-helicoidal body KAUR–40 AGS having an adjustable curvature of the mouldboard:** a – the frontal sight: 1 – the point (chisel); 2 – the share; 3 the mouldboard; 4 – the mouldboard extended lamina; 5 – the trash-board (skim coulter); 6 – the knife; b – the rear sight: 1, 2 – spreaders for support and regulation of the share mouldboard curvature; 3 – the foot of body; 4 – the mouldboard; 5, 6 – the struts

The semi-helicoidal body KAUR–40 AGS (Fig. 3), manufactured by SIA "AGS" in Cesis, has an adjustable mouldboard curvature, as well as angles of the horizontal shape lines (generatrix). This allows obtaining the best mouldboard form corresponding to the particular working conditions.

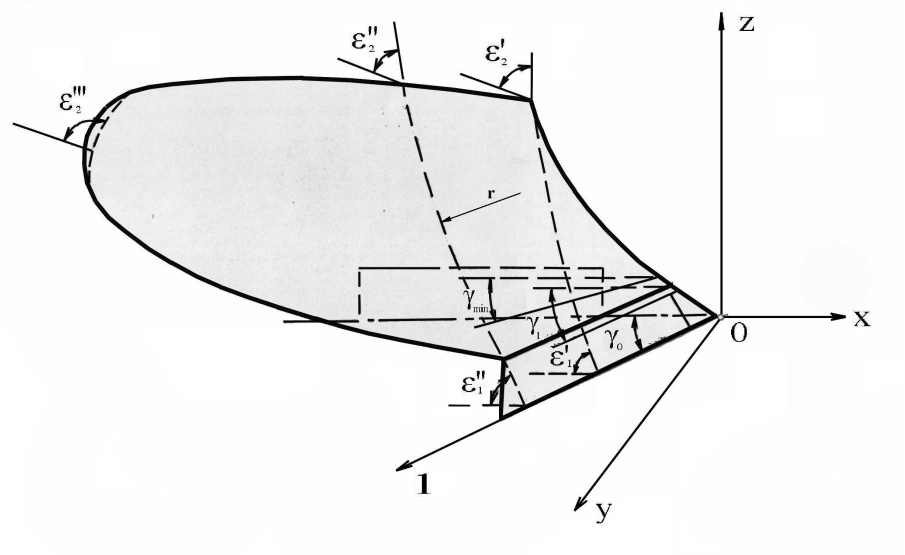

Fig. 3. **Scheme of the plough body with its angular parameters**

Results and discussion

Studies were carried out of a series of share-mouldboard surfaces of the plough bodies. The shapes of the share-mouldboard surfaces were determined according to their profile lines, the parameters - by measuring the angles of or the distances between these profile lines. In order to get the profile lines, a special stand (test bench) was used. The profile lines were obtained by cutting the share-mouldboard surface with the planes running in parallel to the coordinate planes x-z, y-z and x-y, as well with the planes, which are vertical to the plane x-y running perpendicularly to the share edge. The distance between the shape lines (the foot-pace) was 25 mm. The values of the share-mouldboards parameters: the inclination angles γ of the horizontal shape lines, the initial ε_1 and the final ε_2 lifting angles and radius r of the mouldboard were determined using the data about the form and location of the shape lines (Fig. 3).

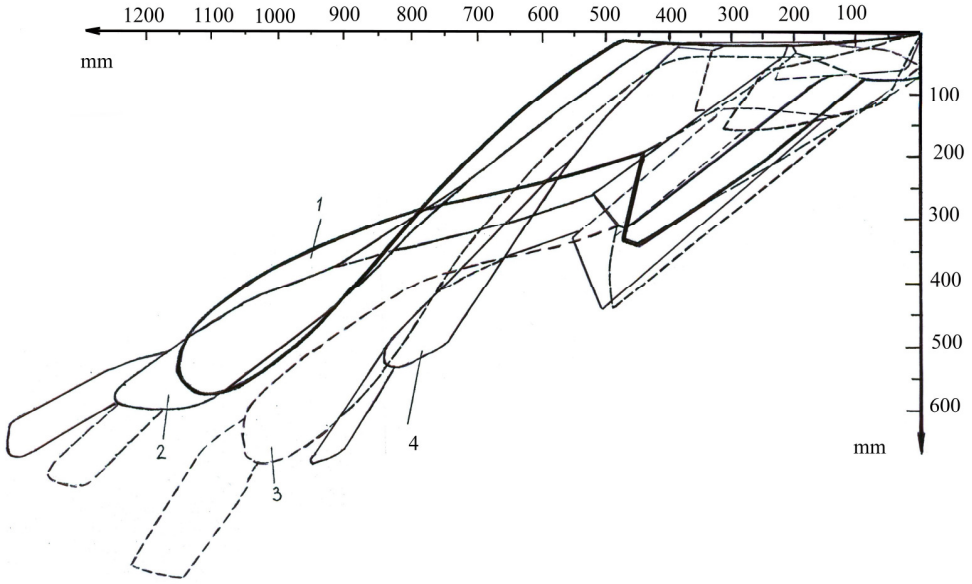

Fig. 4. **The coincidence of the horizontal projection of some bodies (share-mouldboards):** 1 – a helicoidal body SA 600 HL of the Overums-Bruk ploughs; 2 – a semi-helicoidal body No 8 of the Kverneland ploughs; 3 – a semi-helicoidal body KVU-40000 for the PGP loughs; 4 – a culture-semi-helicoidal body PGC–61.000 (PGC–31.000) of the PGP ploughs

Table 1

Parameters of the plough body share-mouldboard surfaces

Symbol of the parameter	Unit of measu-rement	Designation of the plough (trade name)					
		PGP -7 40 Designation of the body		Overums Bruk SA 600 HL	Kverneland body No 8	PN-1-422 P 135-13 Czechy	Optimal value of the parameter
		PGC 61.000	KVU 40.000				
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
γ_0	deg	42	37	31 (38)	38 (42)	43	30...32
γ_{25}	deg	42	36.5	29...24	37	44	29...24
γ_{50}	deg	42	36	29...21	36...28	45	28...21
γ_{75}	deg	41	35...18	27...15	39...20	45	27...15
γ_{100}	deg	41	35...23	26...18	40...21	45...27	27...18
γ_{125}	deg	42	36...23	29...22	41...23	45...36	28...22
γ_{150}	deg	42	36.5...24	30...23	45...24	45...35	29...23
γ_{175}	deg	42.5	37...25	30...24	48...24	45...33	30...24
γ_{200}	deg	43.5	37.5...26	31...26	48...25	45...40	31...26
γ_{225}	deg	44.5	38...39...27	32...27	40...25	45...47	32...27
γ_{250}	deg	45.5	38...40...27	34...30	40...26	45...51	34...30
γ_{275}	deg	46,5	38...42...27	38...33	40...27	45...52	38...33
γ_{300}	deg	48	38...42...32	41...35	40...28	45...52	41...35
γ_{325}	deg	49	39...43...32	43...37	39...30	45...53	43...37
γ_{350}	deg	50.5	42...44...33	44...40	38...35	46...55	44...40
γ_{375}	deg	52.5	43...45...38	45	38...37	48...56	46
γ_{400}	deg	54.5	47...44	46	40...39	48...56	48
γ_{425}	deg	56.5	47...44	-	43...40	48...57	
γ_{450}	deg	57	46	-	41	58	
γ_{475}	deg	-	46	-	-	57	
γ_{500}	deg	-	47	-	-	58	
γ_{p0}	deg	41	48	76	69		
γ_{p25}	deg	43	54...41	76	69		
γ_{p50}	deg	43	56...32	76	69		
γ_{p75}	deg	47	52...36	68	69		
γ_{p100}	deg	65...48	43...35	47	-		
γ_{p125}	deg	65...45	-	-	-		
γ_{p150}	deg	51...46	-	-	-		
γ_{p175}	deg	42	-	-	-		
$\Delta\gamma$	deg	15	10	15	5	15	14…17
$\Delta\gamma'$	deg	1	2	5	2	0	3…5
$\Delta\gamma''$	deg	16	12	20	7	15	16…20
γ_{t250}	deg	45	-	-	-		
γ_{t275}	deg	48	-	-	-		
γ_{t300}	deg	48	-	-	-		
γ_{t325}	deg	48...51	-	-	-		
γ_{t350}	deg	50...57	-	-	-		
γ_{t375}	deg	50...58	-	-	-		
γ_{t400}	deg	43...61	54...90	-	-		
γ_{t425}	deg	46...62	54...92	-	-		
γ_{t450}	deg	46...62	55...95	-	50...84		

Table 1 (continued)

1	2	3	4	5	6	7	8
γ_{t475}	deg	57...62	58...1000	-	48...84		
γ_{t500}	deg	58...62	66...104	-	46...84		
γ_{t525}	deg	58...62	90...109	-	38...95		
γ_{t550}	deg	58...62	-	-	38...95		
γ_{t575}	deg	58...66	-	-	38...94		
γ_{t600}	deg	-	-	-	38...93		
γ_{e275}	deg	43	-	-	29		
γ_{e300}	deg	44	-	-	30		
γ_{e325}	deg	45	-	-	29		
γ_{e350}	deg	46	-	-	28...18		
γ_{e375}	deg	46	-	-	26...16		
γ_{e400}	deg	46	42	-	17...9		
γ_{e425}	deg	45.5	45	-	10		
γ_{e450}	deg	45	46	-	-		
$h_{\gamma min}$	mm	75...100	75...100	75...100	50	0	
ε_1’	deg	33	30	36	30	26	28…32
ε_1’’	deg	33	25	33	28	32	
ε_{1p}’	deg	36...32	29	14	30	-	
α_{1p}	deg	25...23	24	19...20	18...20	20	
ε_2’	deg	65	75	50	77	66	
ε_2’’	deg	99	82	64	90	87	
ε_2’’’	deg	112	120	131	130	114	124…130
$\Delta\varepsilon$’	deg	32	45	14	47	40	
$\Delta\varepsilon$’’	deg	66	57	31	60	55	
$\Delta\varepsilon$’’’	deg	79	90	95	100	88	94…100
α	deg	25	25	20	21	35	
b_s	mm	416	424	340	320	350	
b	cm	35…42	35…50	35	30…50	30…42	45…50
h	mm	470	508	424	444	500	425…480
h_t	mm	620	610	424	500...554	-	
r	mm	520	438	410	455	275	410…460
l_x	mm	850	1130	1226	1280	880	1200…1300
b_y	mm	520	626	566	620	660	
l_{ex}	mm	960	1290	-	1450...1396		
b_{ey}	mm	670	840	-	696...750		

The coincidence of the horizontal projection of some bodies is shown in Fig. 4.

In Table 1 there are given parameters of the share-mouldboard surfaces of the plough bodies mentioned above. In addition, parameters are included in the table showing:

- the inclination angles of the share points – γ_p ;
- the difference between the angles – $\Delta\gamma = \gamma_{top} - \gamma_{0:}$; $\Delta\gamma' = \gamma_0 - \gamma_{min}$; $\Delta\gamma'' = \gamma_{top} - \gamma_{min}$;
- the height of the shape line having a minimum inclination angle - h_{min} ;
- the inclination angles of the shape lines of the trash-boards – γ_t ;
- the difference between the angles – $\Delta\varepsilon' = \varepsilon_2' - \varepsilon_1'$; $\Delta\varepsilon_1'' = \varepsilon_2'' - \varepsilon_1''$; $\Delta\varepsilon_2''' = \varepsilon_2''' - \varepsilon_1'$;
- the inclination angle of the share point in a vertical-longitudinal plane - α_{1p} ;
- the high of the share-mouldboard surface together with the trash-board – h_t ;
- the length of the share-mouldboard surface together with the extended lamina – l_{ex} ;
- the width of the share-mouldboard surface together with the extended lamina – b_y .

The number at index γ shows the height of the horizontal shape lines from the ground.

The coincidence of the horizontal projection of the bodies (share-mouldboards) takes place in such away that the tips of the share points coincide (see Fig. 4). The coincidence for the body KVU 40.000 was more beaked to the left, therefore the contour of its project is beaked (turned) out of the contours of the other bodies (Fig. 4).

It is evident from the horizontal projects (Fig. 4) that the bodies Overums Bruk SA 600 HL, Kverneland No 8 and KVU 40.000 have longer and shallower mouldboards than the bodies PGC–61.000 and P 135-13. Their shape lines and the parameters (Fig. 1) show that the share-mouldboard surface of the body SA 600 HL corresponds to the helicoidal surface, the bottom surfaces of the "Kverneland" No 8 and KVU 40.000 correspond to the semi-helicoidal surface but the share-mouldboard surface of the bottom PGC-61.000 – to the culture-semi-helicoidal surface and the bottom surface of P 135-13 – to the culture body. The parameters of the share-mouldboard surfaces of the first three bodies are closest to the optimal ones (Table 1) when working with the contemporary high-speed tractors [4].

The tests carried out with the ploughs showed that, by their energetic and agronomic indices, the most suitable for the work at contemporary speeds of 2.5…3 m s^{-1} are the plough bodies with helicoidal or semi-helicoidal share-mouldboard surfaces [1, 2, 4]

Conclusions

1. By means of the created test-bench, profilograms (shape lines) were obtained for the share-mouldboard surfaces of some bodies mainly used on the farms of Latvia, as well as their parameters and suitability for the Latvian conditions were determined.
2. The conducted investigations show that more suitable for the work with contemporary high-speed tractors are the ploughs, which have bodies with gently sloping helicoidal or semi-helicoidal share-mouldboard surfaces.
3. The optimal values of the main parameters of the bottoms for contemporary ploughs working at the speeds 2.5…3 m s^{-1} are: the inclination angle of the share towards the furrow bottom – 28…32°; the inclination angle of the horizontal generatrix towards the furrow wall on the initial part of the share-mouldboard surface – 34…38° , on the top - not less than 48° ; the working width of the bottom – 45…50 cm.
4. The use of the bodies having optimal parameters allows attaining good ploughing quality, reducing their draft resistance by 12…20 % and raising correspondingly the efficiency, saving fuel and financial resources for ploughing.
5. The suitability of the new ploughs for the Latvian conditions may be assessed by obtaining shape lines and determining the parameters of the share-mouldboards surfaces of the bodies.

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