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Conceptual Designing of Mould Board's Surface by Geometrical Modeling

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Abstract: In article are considering design-projects of: conceptual mould-board of plough, with decision of task in view by a combination of several constructions; conceptual model of mould-board, with functional useable variations in several agricultural, meliorative and road-building machines; construction of plough's mould-board, with concept selection method by several criteria's. The problems are executed by using constructive geometrical modeling methods, industrial design principles and CAD technologies.

Keywords: Working Surface, Constructive Geometrical Modeling, Selection Criteria, Resource and Energy Saving, Metal Quantity, Multi Functionality, Working Quality, Simple of Technology

1. Introduction

As is well known increase capacity of the machines will allow, reduce the amount of machines these use in production process. However reduction amount of machines possible to obtain by enhancement functional possibilities of these machines' tools, that can bring as well as reduction the material quantity of the machines. So this problem is considered more actual and is one of the modern problems of the industrial design. Since decision of this problem is straight connected with geometric modeling, on which is based modern problems of the industrial design. These aspects actual also in sphere of agricultural engineering, where creation resource and energy saving machines is main engineering activity, key directions in which is considered industrial design [1-3].

Using in agriculture ploughs have a different construction in accordance with their destination. Each construction has its advantage, isomorphic using which in the other construction will bring about a certain loss perfection to this construction. In such events possible to combine the advantage considered construction in one new construction with necessary change [1, 2]. The analyze of existing ploughs' constructions and researches upon their improvement shows that possibility of the creation new construction consisting of combination two or more constructions it is enough are not used and has get prettier prospect. Amongst ensemble of the work, denoted given to problem, as example possible to bring work, referring to designs of the ploughs' constructions [4] and to complicated technical surfaces [5].

Many scientists and specialists were concerned designing of the tools with complicated technical surfaces. For example, in development of mould board surfaces they obtained the expansions of the functional possibilities and reduction material quantity [6], successfully applying theoretical questions of the industrial design [7]. However information about development of the conceptual mould board's models with geometrically combined working surface, universal approaching to several mould boards, author has not. Designing such universal geometric model with combined surface applicable to several mould boards, requires the decisions of the following questions: designing the geometric models of combined surface elements i.e. giving directory curve parameters and generators' positions, also typical cutting surface contour; designing mould boards, on which applicable under designing model; carrying out of the methods of the designing, algorithms and ways to optimization geometric parameters for CAD systems. As is well known technological tools with different working surfaces can consist of one and same geometric surface. For example, moldboards basically consist of ruled surfaces. If

we bring the geometric parameters of different working surfaces two and more moldboards, with such geometric surface, to united parameters, we can get possibility of the enhancement their functional possibilities [3]. In researches period, that carrying out by author, was revealed that using the industrial design, as powerful weapon of the designer-constructor, in designing process of the technical objects, can give the essential results in decision of the resource and energy saving problems, being practical applications of innovation technologies [3]. Using the industrial design in designing process of the technical objects, requires from designer-constructor revealing the problems, which decision are connected with geometric parameters, on which is founded industrial design, as well as way of the decision of these problems, resting in principles of the industrial design [1].

2. Materials and Methods

2.1. Designing Constructive Geometrical Model of Conceptual Moldboard

Amongst the main evaluation criteria's of the plough, depending from its geometric parameters we can note material quantity of construction, easy to manufacturing ability of the moldboard, as well as quality of the executable work [8, 9]. But connect all these quality together is problematic that is connected with complicate designing process of construction. Let we shall conduct the short analysis of ploughs' constructions.

Statement of the problem on designing proposed moldboard. As is well known, the main working organ of the plow is moldboard, having age "sharpened" form, with their own parameters, remains the defining organ at improvement of its construction. For example, shall consider the reversing ploughs, differing more high efficiency and quality of the executable work, not requiring additional preplan agricultural actions after their using. But presence two-set right- and left turning around moldboards does the construction expensive, more material quantity and with big tractional load these are its defects, in counterweight to its advantage [8]. As can be seen from example, point butt of advantages and defects considering construction is its moldboard, having cylindroidal working surface, working in one direction i.e. single-acting. There is design of the technological scheme of the plough with moldboard, working in two (right and left) directions, but with cylindrical working by surface that does not provide the satisfactory turn of the layer [4]. So moldboard of the plough with cylindroidal working surface is considered in agricultural engineering wide-spread, having good crumbling and turning around factors. But this advantage withstands their defect - low ease of manufacturing of the fabrication no developable surfaces [8, 9]. According to this discourses follows that combination, from these constructions combining in itself their advantages, and avoiding their defects, gives the decision given problems. The conceptual approach to this problem is reduced to creation design-development of the moldboard, satisfying aforesaid requirements flat plowing and turn of the layer i.e. to using advantage reversing and right turning around plough with cylindroidal surface. For refusing of doubled moldboard its under designing construction must realize work in two directions and have turning around ability. Problem shall solve on base of the projection and constructive-geometric modeling methods [7, 10].

Constructive-geometric model of the under designing moldboard. As is well known mould board surface is divided on three technological areas:

1-area raises the layer, cutting it, here participates the plowshare and lower part of moldboard though they physically are a separate detail, fluent their butting logically form one working surface - *plowshare*;

2-area takes the layer, crumbling it, here participates the average part of moldboard - *breast*;

3-area postpones the layer, turning around it, here participates the higher part of the moldboard - *wing*.

As moldboard is seen though physically is one detail, logically consists of two parts - breast and wings. We shall consider the problem of division to surfaces of the moldboard on two parts, fluent butt-jointing higher part of the moldboard and wings. Such butting possible to allow, since it there is and in lower part of moldboard. As a result we can easy approximate complicated no developable cylindroidal surface, with pieces of typical cutting surfaces, as follows cylinder and cone [5, 7]. Such component surface in first will have high ease of manufacturing of the fabrication [11, 3], in second saves turning around ability, in third gives enable designing of the moldboard, working in two directions (Figure 1. a, b) [12].

Shall we revise the component parts of the designing moldboard. It is possible offer the new design of the two-way plowshare, both ends which have tapered chisel-shaped form, alternately executing nose and tail function. Thereby, plowshare will logically consist of three parts (nose, average and tail), having form on carrying cone-shaped, in medium flat, but in higher part of the cylindrical surface. This can provide entering a carrying in monolith, cutting and lifting its average part, and climbing down it with tail part with smaller resistance. The line of the butting between higher part of the plowshare and breast is general forming for both cylindrical surfaces. And cylindrical surface of moldboard breast will equally work in shift to the right and in left side. That designing moldboard worked in two-way mode, separate the wing to shift to the right and left part. The path of the upper point of the layer, passing on surfaces of the moldboard, defines the border between right and left wing. The line of the butting between breast and wings is general generator simultaneously cylindrical surface of the breast and cone-shaped surface of wings.

That moldboard worked in two directions equally, we shall design its form symmetrical. That moldboard is a three-dimensional object, shall conduct the plane of symmetries to perpendicular blade of the plowshare, in the middle it. We dispose directing curve of moldboard breast's surface on this

plane. The position of its generators, as is well known, is defined by angle of the slopping for walls of the furrow, in both positions of the work. The wings' surfaces are defined by position of upper generator. As directing curve we can give arc of the ellipse, with girth of the top on big axis, disposing this part on surfaces of the wings, for the reason giving its necessary steepness of reversing [3].

It is possible to note the following typical lines on working surface of the designing moldboard: *1* - directing curve - a line of the mirror image; *2,2′* – right and left path of the upper point of the layer; *3,3′* - right and left line of the intersection to surface with furrow wall; *4,4′* - furrow (field) edges; *5,5′* - furrow edge of the prototype moldboard; 6 - a line of the butting of the plowshare and breast; *7* - a line of the butting breast and wings. *S* - a top of the cone-shaped surfaces.

The projection-geometric model of the designing moldboard. For determination contour line of designing moldboard we can use projection modeling. On base of the traditional designing methods we use the layer reversing scheme and design the preliminary projections of frontal and top views (Figure 1. c).

Let dispose the scheme so that top view is general for connecting it with both frontal views in right and left reversing operation modes. The directing curve in top view is an axis of the mirror image. So in the beginning it is enough to determine one half to projections of the body. Mirror reflecting second half and having installed projection relationship, find the second half on frontal view. Hereon we define the furrow edges, choosing optimal form of the cross-section of the turned around layer. They simultaneously are a field edge for back. Optimizing form of the cross-section by geometric modeling for designing moldboard, shall get rhomboid form that on agricultural considerations have even row advantages, as "rhombic plowing" [8].

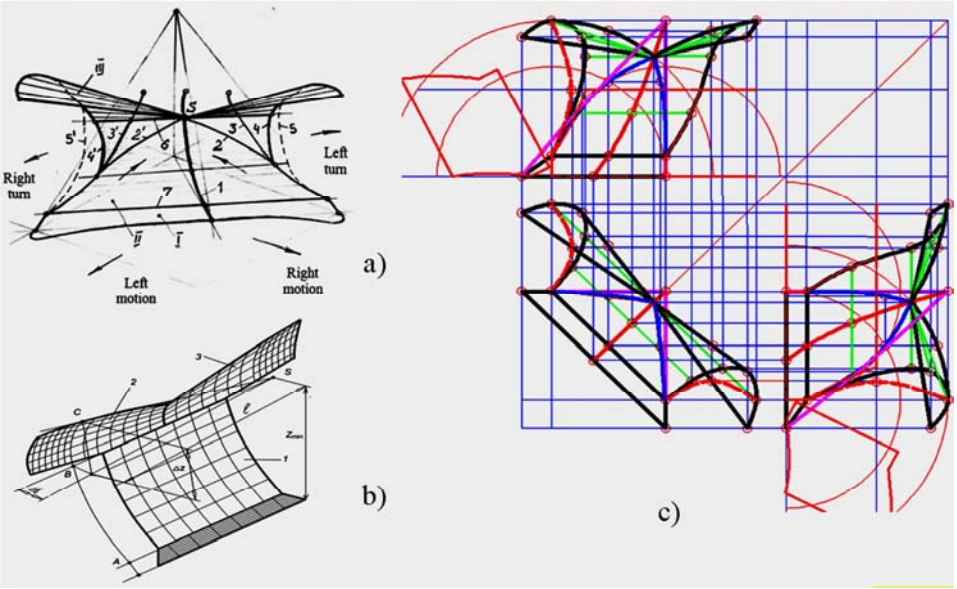


Figure 1. *Designing constructive geometrical model of conceptual moldboard: a) sketched model; b)patented computer model; c) projection model of designing moldboard surface.*

2.2. Designing the Conceptual Model of Moldboards' Surface

For adduction geometric parameters different working surfaces to united parameters, founding on positions of the moldboard surfaces theory [11] and descriptive geometry [13], as well as on results of the researches carried on by author [3], it is possible consider given the ruled surfaces:

1. The directing curve, which is assigned by its plane, is and section to surfaces. All parallel sections of cylindrical surface are identical (Figure 2. a.), conic surface are similar (Figure 2. b.), and cylindroidal surfaces are different (Figure 2. c.).
2. Generators of ruled surfaces can be parallel in cylindrical surfaces (Figure 2. a.), secant in conic surfaces (Figure 2. b.), crossbreeding in cylindroidal surfaces (Figure 2. c.).
3. The section of moldboard surface by counter can be complementing (Figure 2. a.), have a general part (Figure 2. b.) or mirror reflected (Figure 2. c.).

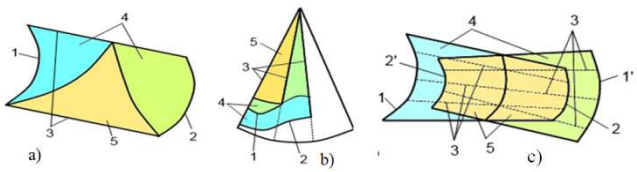
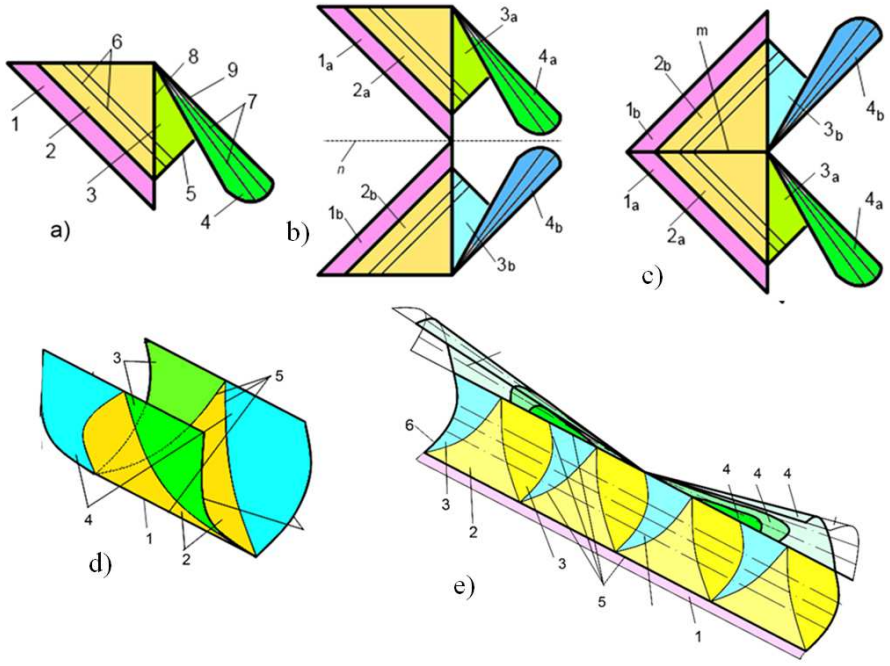


Figure 2. *Giving the ruled surface for moldboard: 1,2-directories, 3-generators, 4- basic surface, 5-typical cutting surface.*

Optimizing directing curve parameters, assigning generators positions, as well as butting counters of working surfaces we will have possible to use them to several moldboards. Supporting in these positions, using methods of constructive-geometric modeling [10], we will have possible to designing the universal geometric model of required

working surfaces (Figure 3.). This allow to enhancement functional possibilities of designing moldboards [1]. Conceptual model of the moldboard with geometrically combined working surface is offered on base of the foregoing positions. There are brought possible variants of the functional using the conceptual model, they are considering by author in system AutoCAD and CATIA, on given conceptual design was received patent for useful model "Plough's moldboard" [12].



1-plowshare, 2-basic and 3-ancillary breasts, 4-wings, 5-joints, m-edge and n-axis of reflections

Figure 3. *Conceptual moldboard: a) for plough; b) for furrower; c) for irrigation ditch; d) for grab bucket; e) for bulldozer blade.*

2.3. Designing of Moldboard Constructions by Concept Selection Method from Existing Constructions

We shall consider as example designing process of plough moldboards' working surfaces (Tables 1 and 2), which has complicated technical surface, centuries-old changes on improvement of its construction and universal geometric model. All these factors in one or another degree possible to take into account in designing process of the different technical facilities with moldboards and allow to do the findings that using the industrial design can give the essential results, including and on resource and energy saving. The designing carried on base of several constructions [4, 6, 8, 14, 15], herewith are taken into account also some criteria of the choice, connected with resource and energy saving questions, as one of the main factor, defining consumer requirements. The criteria's are valued comparatively, with provision for geometric parameters (Table 3).

Table 1. *Reviewed constructions.*

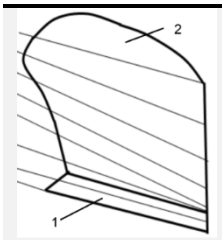
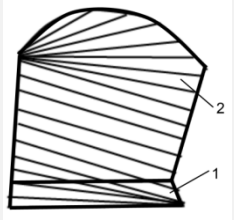
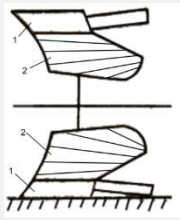
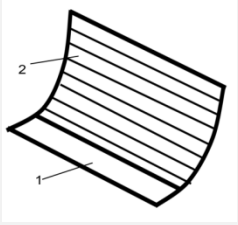
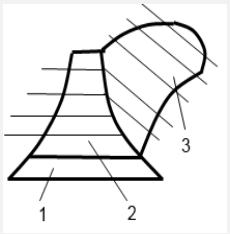
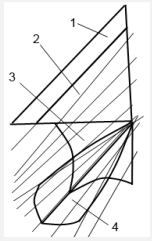
 Construction – A	 Construction – B	 Construction – C
 Construction – D	 Construction – E	 Construction – F

Table 2. *Descriptions of reviewed constructions.*

№	Constructions	Using in ploughs	Type of moldboard	Working surface	Moldboard parts
1.	A	In single-acting ploughs.	Classical.	Cylindrical	Plowshare. Breast.
2.	B	In single-acting ploughs.	Eexperimental.	Geometrically combined	Plowshare. Breast.
3.	C	In reversing ploughs.	Doubled	Cylindroids	Plowshare. Breast.
4.	D	In turning ploughs.	Ddouble-sided	Cylindrical	Plowshare. Breast.
5.	E	In single-acting ploughs.	Separately moldboard and wing	Geometrically combined	Plowshare. Breast. Wing
6.	F	In turning ploughs.	Separately turning moldboard and right and left wings.	Geometrically combined	Plowshare. Breast. Right wing. Left wing.

Composition matrix of evaluations of constructions, on the main criteria's of product connecting them with geometric parameters. At evaluation criteria's we take value "-" - for defect, "+" - for advantage and "0" - neutral.

Table 3. *Comparative evaluations of reviewed constructions depending on geometrical data's.*

№	Evaluation criteria's	Constructions					
		A	B	C	D	E	F
	Energy-saving	0	+	-	0	+	0
	Material quantity	+	+	-	0	+	0
	Multifunctional ability	-	-	-	-	+	0
	Quality of the executable works	-	0	0	-	0	0
	Easy to manufacturing ability	-	-	-	+	-	-
	Amount by " – "	3	2	4	2	3	1
	Amount by " 0 "	1	1	1	2	1	4
	Amount by " + "	1	2	0	1	1	0
	Amount evaluations	-2	0	-4	-1	-2	-1
	Rating	3	1	4	2	3	2

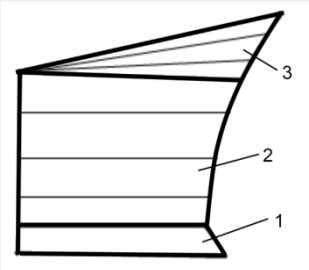
Shall we decipher, for example, energy saving criterion, connected with geometric parameters of the moldboard: mass depending on its form and working surface parameters, allowing control its smoothness and optimize the path of the moving particles, which influence upon friction (Table 4).

Table 4. *Comparative evaluations of energy-saving criteria's of reviewed constructions.*

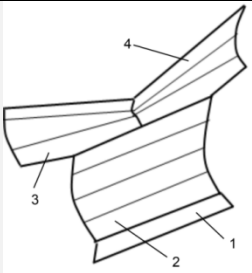
№	Energy-saving criteria's	Constructions					
		A	B	C	D	E	F
1.1.	Metal smoothness friction	-	-	-	+	-	-
1.2.	Trajectory friction	-	+	-	-	+	+
	Common friction	-	0	-	0	0	0
2.	Relative mass of moldboard	+	+	-	0	+	0
	Common energy-saving	0	+	-	0	+	0

Results of the evaluation of the criteria's spare once proves the advantage of construction "B", pointing to the most further designing direction of the moldboard construction with geometrically combined working surface [3]. On results of researches carried on by author offering moldboard constructions, designed on advantages of reviewed constructions (Tables 5 and 6).

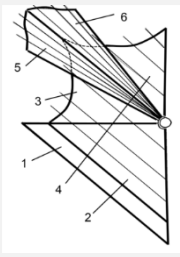
Table 5. *Offering designed constructions.*



Designed construction – G



Designed construction – H



Designed construction – I

Table 6. *Descriptions of designed constructions.*

№	Constructions	Using in ploughs	Type of moldboard	Working surface	Moldboard parts
1.	G	In single-acting ploughs.	Separately moldboard and wing	Geometrically combined	Plowshare. Breast. Wing.
2.	H	In turning ploughs.	Separately moldboard and right and left wings.	Geometrically combined	Plowshare Breast. Right wing. Left wing.
3.	I	In turning ploughs.	Separately turning moldboard and right and left wings.	Geometrically combined	Plowshare Basic breast. Right ancillary breast. Left ancillary breast. Right wing. Left wing.

3. Conclusions

Proposed design of the plough's moldboard, as geometric model, provides geometric parameters management of designing moldboards that allows to construct on motivated parameters of the plough's moldboard, agreeable to that or other agricultural conditions. In this case purpose of the designing possible to consider executed, since moldboard with two-way working surface has identical parameters that allows to operating flat plowing without two-set moldboard. The second advantage possible to note the compound surface from parts of developable surfaces, having high ease of manufacturing of the moldboard fabrication. And the third, optimum rhomboid form of the cross-section. On given problem are further researches on constructive modeling of other moldboard tools and development of the algorithms under investigation object, also planning undertaking the designed moldboards in CAD/CAM/CAE systems. Proposed models possible to use in designing tools with moldboards used in road building, mining and agriculture engineering spheres, as well as on designing the complicated technical surfaces applicable in aircraft, shipbuilding and other engineering spheres. Introducing the designed models in CAD/CAE/CAM system in prospect to allows to realize the designs production.

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