Chapter

Application the Geometric Modeling Methods and Systems in Design Engineering and Manufacturing on Example of Agriculture Engineering

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Abstract

Geometric modeling, as widely used synthetic design method in design engineering and manufacturing, is a theoretical base for geometric modeling application (industrial design) and geometric modeling systems (CAD systems). Therefore this chapter is devoted to application geometric modeling methods and systems in design engineering and manufacturing. For example, we will considered designing agriculture machines' tools by following case studies: development models of bulldozer's moldboard by geometric modeling method (for design engineering); screening the concept select process of plow's moldboard (for design engineering and manufacturing); determining integrative role of geometric modeling systems in agro machinery tools' PLM (for manufacturing).

Keywords: geometric modeling methods and systems, geometric modeling application, product lifecycle, design engineering, multifunctionality, moldboard's surface, product manufacturing criterions and properties

1. Introduction

Today, world has seen a marked increase in the variety of techniques used in all areas of human activity, in terms of their functionality. Therefore working out of working bodies expanding their functionality is one of the major problems of modern engineering and design activity. This has become especially important in the context of the transition of the Republic of Uzbekistan to a new stage of development, where fundamental reforms of management in agriculture are taking place, grandiose projects in construction are being implemented, as well as great attention is being paid to the development of settlements [1]. Decision of these problems is straight connected with geometric modeling on which modern problems of design engineering and manufacturing are based. Extending the functional possibilities of agricultural machines is one of the main ways for design engineering and manufacturing of modern agricultural machines, which can be realize by design engineers. Particularly, it actually in modern agricultural production, which based on precision agriculture technologies, where using such machines must provide: reduction of cost, conservation of ground fertility, saving energy-resources, improvement labor conditions, and increase machines capacity. One of the efficient ways to decide these problems is using geometric modeling in design engineering of agriculture machines' tools. Geometric modeling, as one of varieties synthetic methods' of designing, is a theoretical base for production design and CAD technologies, which widely use in design engineering and manufacturing [2–4].

The development of agricultural tools mankind has been engaged for centuries. In 1830, the Italian abbes Lambruschini and Ridolfi were prompted by the helical surface (helix) to plow's moldboard. In the late nineteenth century, Russian academician V.P. Goryachkin laid the foundation of the science "Agricultural Mechanics". Since then, many scientists from America, Europe, and other countries have developed various methods of research and modeling in the mechanization of agriculture. These methods mainly solve problems by analytical and experimental methods, although synthetic methods have a number of advantages in solving some problems. The reason that synthetic methods, as geometric modeling, until recently used rarely, was the advantage of the use of information technology in analytical methods. However, the widespread use of information technology in synthetic methods since the end of the twentieth century, their capabilities have become much more effective. The advantage of geometric modeling is its simplicity and clarity. It as a basis of synthetic methods of development of technical objects has innovative character that modern production demands increase in a variety of production, reduction of terms of their development, and also automatization of these processes [5–8].

2. Developing the Bulldozer's moldboard by geometric modeling method for design engineering

2.1 Designing directions of mold board's working surface

Considering decision of above-mentioned problem on example of moldboard type tools give clarity on this problem. Moldboards, as main working body of bulldozers, graders, and other special equipment, are designed to perform preparatory work in agriculture and melioration, ground works in road building and engineering preparation of territories, as well as other works, for example, in municipal service. Classic moldboard has frontally positioned cylindrical working surface, on which the earth or other mass must move, formed as a "dragging prism" in the required direction and quantity [9, 10]. To expand functionality of moldboards, there are have developments in various design options, with a changing position of the working surface or using other working surface (**Table 1**). But, these developments' directions aimed to expand functionality of moldboards, to perform definite works [9, 11]. The decision of these problems is straight connected with geometric modeling which is based on modern problems of industrial design [2–4]. The result of using industrial design at development of moldboard type tools on base of constructive geometric modeling is a "design-project" of moldboard, which possibly produce three working surface types design. Design-project is geometric model of developing object which has only geometric parameters, but these parameters are given on base of forward given conditions of technical/technological parameters and have close connections with them. We shall consider the design-project of

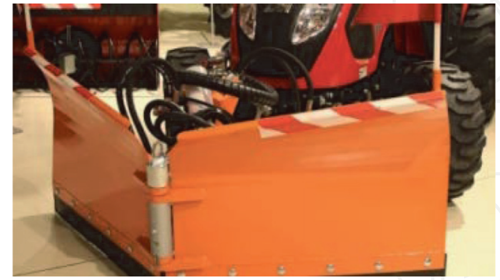
No.	Moldboards' construction	Surface type	No.	Moldboards' construction	Surface type
1		Cylindrical (Poland)	4		Combined (Czech)
2		Conidial (Finland)	5		Cylindroidal (Sweden)
3		Conical (USA)	6		Planar (France)

Table 1.
Types of bulldozer moldboards' construction and their surface.

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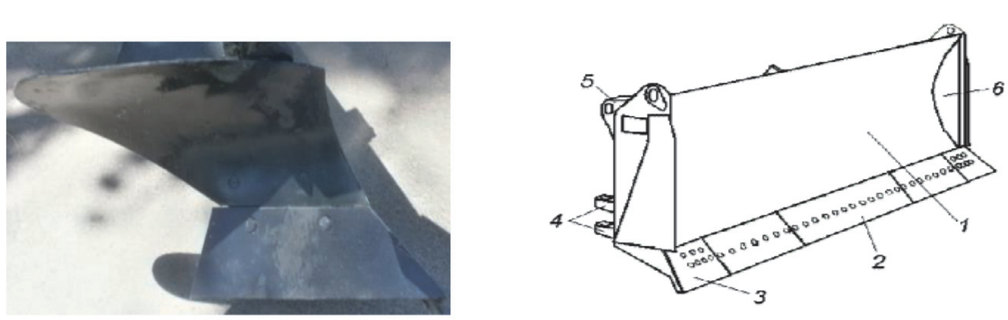
moldboard's working surface consisting of section. For base of the models, we take multi-function surface consisting linear surfaces, which are broadly used for designing moldboards (**Table 2**). Design-project of mold board's working surface by constructive geometric model applicable for work execution of characteristics: technical, technological, and economical factors of designed technology, allows more flexible control its functional possibility, solving constructive problems [2, 12, 13]. The analysis of existing moldboard design and studies upon their improvement shows that creation new design increasing their functional possibilities, way of constructive geometric modeling, have a broad prospect [9, 11, 12, 14, 15]. With standpoint of the constructive geometry design of moldboard's working surfaces will possible divide into three types: (1) construction consisting traditional (one-piece) surface design (**Figure 1**); (2) construction consisting sectional (parts) surface design (**Figure 2**); and (3) construction consisting elemental (plates) surface design (**Figure 3**). Herewith possible sweeps away prospects of primary using these design on example: (1) traditional surface design for producing polymeric moldboards; (2) sectional surface design for expansion of functional possibilities and increasing manufacturability of moldboards' producing; and (3) elemental surface design for best managing manufacture, functional, working, and other quality moldboards. Development of moldboard's working surface, applicable to execution of different works, increases their operational,

No.	Geometry of moldboard's surface	Using in machines
1	Frontal planar surface	Channel defogger's moldboard
2	Inclined planar surface	Bush cutting bulldozer's moldboard
3	Frontal cylindrical surface	Frontal bulldozer's moldboard
4	Inclined cylindrical surface	Bucket scraper's moldboard
5	Frontal conical surface	Grader's moldboard
6	Inclined conical surface	Frontal plow's moldboard
7	Cylindroidal surface	Universal plow's moldboard
8	Conidial surface	High-speed plow's moldboard
9	Hyperbolic-parabolic surface	Hyperbolic body plow's moldboard
10	Helicoid surface	Helicoids body plow's moldboard
11	Torso surface	Cultural plow's moldboard
12	Combined surface	Combined body plow's moldboard

Table 2.
Geometry of moldboard's surface and their using in machines.



a) *b)*

Figure 1.
Traditional (one piece) construction of plow (a) and bulldozer (b) moldboard's surface.

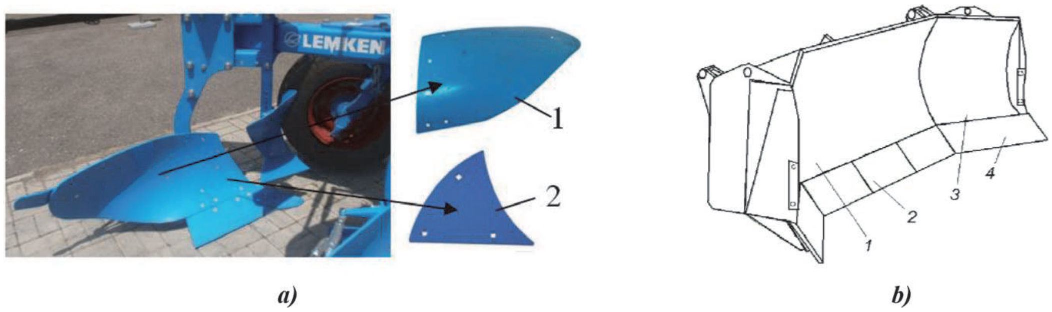


Figure 2.
Sectional (parts) construction of plow (a) and bulldozer (b) moldboard's surface: "1-wing" and "2-breast" of plow's body; "2-frontal" and "3-side" sections of spherical moldboard of bulldozer.

Figure 3.
Elemental (plates) construction of plow (a) and bulldozer (b) moldboard's surface: 1-right, 2-middle and 3-left guiding frames, 4-right and 5-left formative plates (*construction offered by author).*

economic, and technological performance. Therefore, the design-project of a constructive geometric model of the moldboard's working surfaces, although there are designs of such equipment, allows more flexibility manage the functional capabilities of moldboard and solve above-described design problem [2, 12, 13].

2.2 Geometric modeling of transformable moldboard's surface

Linear surfaces are main use type of in moldboards' working surface. Lines $\boldsymbol{l}$ are formatives of cylindrical working surface $\boldsymbol{\Phi}$, and all of them are parallel to each other. In considering task they have horizontally position. Working surface $\boldsymbol{\Phi}$ is formed by directory curve $\boldsymbol{m}$. Type of this curve is planar and it can be given by plane $\boldsymbol{P}$. For frontal moldboard, the plane $\boldsymbol{P}$ is located perpendicular to formative lines in the middle of them. This plane intersects the working surface $\boldsymbol{\Phi}$, and divides it into two equal $\boldsymbol{\Phi_a}$ and $\boldsymbol{\Phi_b}$ parts, simultaneously being the symmetry plane of these working surfaces. Let us choose the straight line $\boldsymbol{k}$ on the symmetry plane, through which we can carry out the beam of planes. These planes intersect with the $\boldsymbol{\Phi_a}$ and $\boldsymbol{\Phi_b}$ working surfaces to form intersection curves. Let us define these planes on both sides of the symmetry plane $\boldsymbol{P}$, respectively, $\boldsymbol{P_1, P_2, \dots, P_n}$ and $\boldsymbol{P_1', P_2', \dots, P_n'}$, as well as the intersection lines on the working surfaces $\boldsymbol{\Phi_a}$ and $\boldsymbol{\Phi_b}$, respectively, curves $\boldsymbol{m_1}$, $\boldsymbol{m_2, \dots, m_n}$ and $\boldsymbol{m_1', m_2', \dots, m_n'}$. In this case, the angles between planes and plane of symmetry $\boldsymbol{P}$, respectively, denote $\boldsymbol{\alpha_1, \alpha_2, \dots \alpha_n}$. Each pair of curves $\boldsymbol{m_1, m_1'}$; $\boldsymbol{m_2}$, $\boldsymbol{m_2'}$; … $\boldsymbol{m_n, m_n'}$, formed, respectively, by pairs of planes $\boldsymbol{P_1, P_1'; P_2, P_2'; \dots P_n, P_n'}$, are symmetrical, where $\boldsymbol{k}$ is the axis of mirror reflection of pairs of curves on working surfaces $\boldsymbol{\Phi_a}$ and $\boldsymbol{\Phi_b}$ (**Figure 4a**). Therefore, when the pairs of $\boldsymbol{P_i}$ and $\boldsymbol{P_i'}$ planes rotate together with $\boldsymbol{\Phi_a}$ and $\boldsymbol{\Phi_b}$ surfaces around the $\boldsymbol{k}$-axis by the corresponding angle $\boldsymbol{\alpha_i}$, $\boldsymbol{P_i}$, and $\boldsymbol{P_i'}$ planes, as well as their $\boldsymbol{m_i}$ and $\boldsymbol{m_i'}$ curves are match and form a

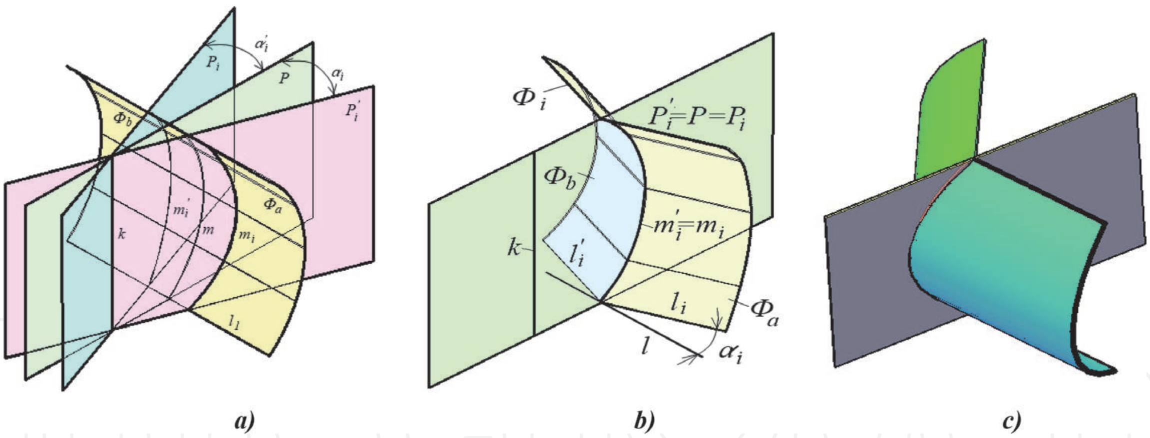


Figure 4.
Developing the conception of moldboard with bilateral action working surface. a) geometric model for designing moldboard with bilateral working surface; b) moldboard for outside action; c) moldboard for inside action.

new working surface. As a result, an edge separating the working surface into two halves is formed on the working surface. On the basis of this model, it is possible to develop various constructive variants of transformed moldboard's design models, allowing to transform from one working surface in another. It is known that when designing complexity technical forms, the considering surface is mentally different by "*geometric*" and "*working*," since from the same surface, it is possible to obtain different working surfaces [4, 11]. Therefore, it can form new required working surface $\boldsymbol{\Phi_i}$ by proposed model, that is, by rotating working surfaces $\boldsymbol{\Phi_a}$ and $\boldsymbol{\Phi_b}$ around the axis $\boldsymbol{k}$ in angle $\boldsymbol{\alpha}_i$. Although given $\boldsymbol{\Phi}$ and newly formed $\boldsymbol{\Phi_i}$ surfaces are cylindrical, they have different working surfaces with different functional properties, where $\boldsymbol{\alpha}$ becomes the control parameter in the formation of $\boldsymbol{\Phi_i}$. New working surface $\boldsymbol{\Phi_i}$ improves directional action of the moving layer mass on the outside (**Figure 4b**) and from the inside (**Figure 4c**) than given surface $\boldsymbol{\Phi}$.

2.3 Geometric parameterization of moldboard's surface

2.3.1 Giving the axis of rotation of the working surface

The process of formation of the required working surface $\boldsymbol{\Phi_i}$ can be controlled, besides the parameter $\boldsymbol{\alpha}$, also the position $\boldsymbol{k}$. In the model under consideration, position of rotation axis $\boldsymbol{k}$ is vertical and has a certain distance relative to $\boldsymbol{\Phi_i}$. However, change in the position of $\boldsymbol{k}$ significantly affects the formation of $\boldsymbol{\Phi_i}$. Here we can consider two parameters of $\boldsymbol{k}$: the change in the distance $\boldsymbol{f}$ defined between fixed points $\boldsymbol{k}$ and $\boldsymbol{m}$, for example, the base of $\boldsymbol{k}$ and sock $\boldsymbol{m}$ on a horizontal plane; and the change in the angle of inclination $\boldsymbol{\beta}$ to the horizontal plane. At the same angle $\boldsymbol{\alpha}_i$ and shape of the directory curve $\boldsymbol{m_i}$, changing $\boldsymbol{f}$ will lead to change in the relative position of pairs of directory curve $\boldsymbol{m}_i$ and $\boldsymbol{m}_i'$, which will lead to a change in the design parameters of moldboard's working surface $\boldsymbol{\Phi_i}$. Among the options (**Figure 5**) considered by the author, the variants b) chord $\boldsymbol{AB}$ and d) tangent in point $\boldsymbol{C}$ are selected as acceptable for this problem, when it will be possible to neglect parameter $\boldsymbol{f}$, that simplifies the problem. Though other variants also have such working surface, it they can lead to complication of moldboard's constructive parameters. However, when the surface $\boldsymbol{\Phi_i}$ is formed, in the variant *d* rotation is performed in the opposite direction than in variant *b*. The rotation angle $\boldsymbol{\alpha}$ is selected with $\boldsymbol{0 < \alpha < \alpha_{max}}$, provided that the $\boldsymbol{P}_i$ and $\boldsymbol{P}_i'$ planes must intersect all formative lines of surfaces $\boldsymbol{\Phi_i}$, where $\boldsymbol{\alpha_{max}}$ is equal to $\boldsymbol{tg\alpha = (l/2)/b}$, and $\boldsymbol{b}$–extension of directory curve.

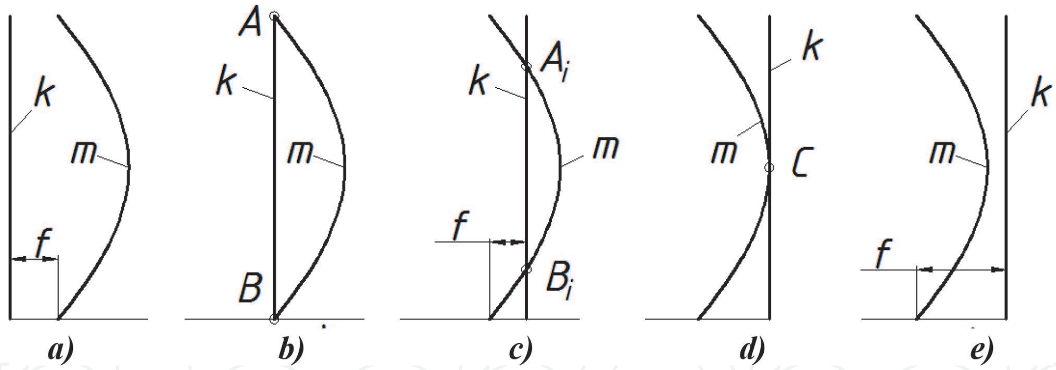


Figure 5.
*Variants of rotating axis (**k**) positions of working surface relatively to directory curve **m**. A, B, C – extremely points of working surface, **f** – distance between axis and extremely points.*

2.3.2 Parameters of designed working surface's directory curve

It is necessary to mark the parameters by shape and position of the directory curve ***m*** of the surface ***Φ***. According to the problem, the shape of directory curve ***m*** is flat and smooth, with a certain curvature and a concave side forward. Since these properties of directory curve remain low during the transformation of the surface, they will be identified as the topological parameters of the curve that determine its shape. Therefore, such surface parameters as its shape and curvature also remain low even when a new surface Φ_i is formed. The position of the curve is defined by two parameters: its offset–***b*** and height–***h*** of the curve. They are defined as constructive parameters, as they define the design of moldboard. The following variants of mutual arrangement of constructive parameters ***m***, determined by the position of characteristic points, can be distinguished (**Figure 6**). The lower (***A***) and upper (***B***) points define ***h***, and the outermost left and right (pairs of from points ***A***, ***B***, ***C***) points define ***b***. These directory curve variants can be selected when designing the moldboard depending on the work performed by it. When ***f*** is changed in vertical position ***k***, the moldboard's overall height h' also remains low. Parameter $\delta b_{max} = b_i - b$ obtained after formation of an edge of the surface Φ_i edge, is located opposite to the point at which the rotation axis ***k*** passes (*right/left*–on the chest or *upper/lower*–on the toe).

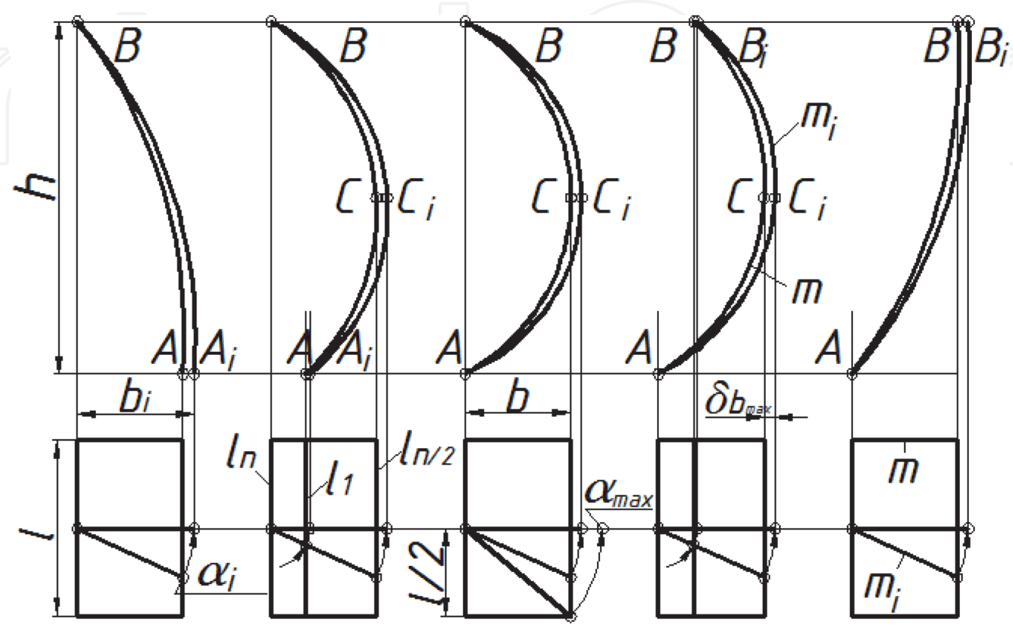


Figure 6.
Variants of relative positions of directory curve and it's constructive parameters.

2.3.3 Parameters of designed working surface's formative lines

Criteria for choosing the variants of the characteristic points of the directory curve ***m*** by ***h*** and ***b***, in the design of the moldboards can be explained by linking these points to the characteristic positions of the formative lines ***l***. For example, we distinguish the following positions of the formative lines ***l***, passing through characteristic points ***m*** in width ***b*** with respect to ***h***: upper, lower, frontal, rear, and middle (by ***h*** or ***b***), and determine their influence on the nature of the movement of the layer mass on the working surface of the moldboard (**Table 3**). It follows from **Table 3** that the nature of the layer mass movement along the working surface can be controlled by changing the relationship ***h*** and ***b***, by changing angle $\boldsymbol{\beta}$ of the ***k***-axis inclination. In contrast to vertical position, the inclination ***k*** at angle $\boldsymbol{\beta}$ forwards or backwards gives the working surface, in addition to improving the shift of the transported mass to the side when it is horizontally leveled (**Figure 7a**), also improves the functional properties of the inclined slopes (**Figure 7b**) and lifts (**Figure 7c**) from the transported mass. This is achieved by changing the positions of formative lines ***l***, which also represent the plowshares, relative to the horizontal plane by angle $\boldsymbol{\varphi}$, after formation $\boldsymbol{\Phi_i}$. The angle $\boldsymbol{\varphi}$ can be determined by the projection model based on the principles of descriptive geometry [16], superimposing horizontal plane with frontal, by rotating it in 90°, on the front projection we combine projections ***k*** and ***l*** (**Figure 7d**). Rotate ***l*** by the angle $\boldsymbol{\alpha_i}$, marking with $\boldsymbol{l'}$, and easily find the front projection $\boldsymbol{l_v'}$. Since ***l*** rotates on a frontal projection plane perpendicular to ***k***, the rotation circle ***l*** is projected on a horizontal plane as an ellipse. Using the projecting rays, we find $\boldsymbol{l_h'}$ and determine the $\boldsymbol{\varphi}$—the angle of

No.	On width *b*, in respect of *h* and through points			Nature of the moving the moveable mass on worker of the surfaces
	Anterior	Average	Posterior	
1	Superior–*B*	Not available	Interior–*A*	Powerfully postponed in before.
2	Superior–***B***	Interior–***A***	Average–***C***	Partly is taken on breast and powerfully postponed in before.
3	Superior/ Interior–***B*/*A***	Not available	Average–***C***	Completely taken on breast and powerfully postponed in before.
4	Interior–***A***	Superior–***B***	Average–***C***	Completely taken on breast and weakly postponed in before.
5	Interior–***A***	Not available	Superior–***B***	Completely taken on bosom.

Table 3.
Formatives' positions and their influence to working surface nature.

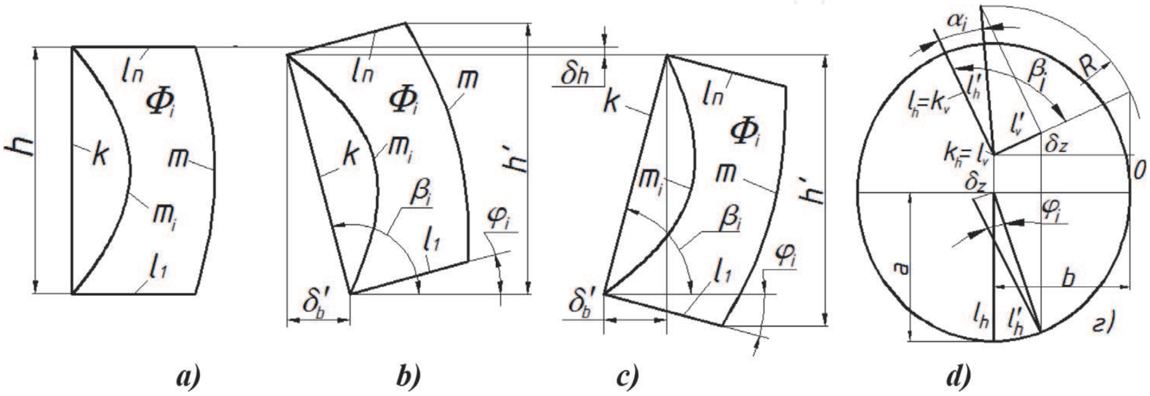


Figure 7.
Determining the geometric parameters of inclined working surface. Working surface positions: a) vertically; b) inclined to forward; c) inclined to back; d) geometric model for determining parameters.

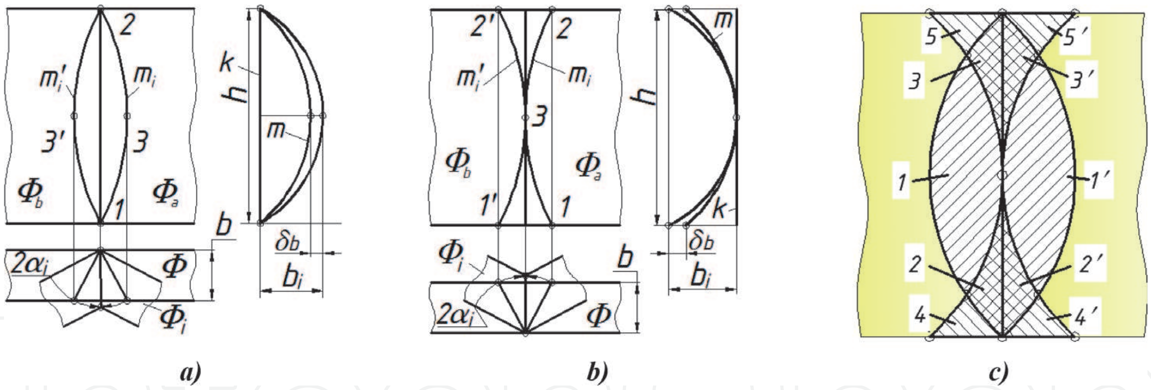


Figure 8.
Developing the construction of moldboard with bilateral action working surface. a) for outside action; b) for inside action; c) sections of working surface.

inclination $\boldsymbol{l}$ to the horizontal plane by the rectangular triangle method, also considered as the angle of inclination to the plowshare. After transformation of the working surface $\boldsymbol{\Phi}$ by $\boldsymbol{\Phi_i}$ with inclined $\boldsymbol{k}$, the overall height of the blade $\boldsymbol{h'}$ increases, although $\boldsymbol{h}$ decreases by $\boldsymbol{\delta h}$. The upper part of the ridge tilts forward or backward relative to the lower part, shifting by $\boldsymbol{\delta b'}$. As a result of the transformation of the working surface, the lengths of corresponding $\boldsymbol{l_i}$ formatives change within the range of $\boldsymbol{0 < \delta b < \delta b_{max}}$, displacing the ends of the surfaces forming the ribs, change. At the point at which the axis of rotation $\boldsymbol{k}$ passes, the length of $\boldsymbol{l_i}$ is equal to $\boldsymbol{\delta b = 0}$ and the nose (upper or lower) part of it is equal to $\boldsymbol{0 < \delta b < \delta b_{max}}$.

2.4 Sections of designed working surface

The definable parameters of $\boldsymbol{\Phi_i}$ has two variants, on base of descriptive geometry principles, make sure that under alike $\boldsymbol{\alpha_i}$ parameters $\boldsymbol{\Phi_i}$ is also alike, but mutually negative (**Figure 8a, b**) [16]. This allow to combine two variants in one construction, which will enlarge the functional possibilities of designed moldboard (**Figure 8c**). It will select five compartments of working surfaces on intersection lines. Alternate switching-on or switching-off corresponding compartments will enable to work moldboard in three modes: moving the layer mass frontal, outside, and inside. The proposed geometric model of transformed working surface allows to development multifunctional moldboard. This development is intended for designing organization to production of specific machines. Parameterization of moldboard's working surface relieves designer's work, increases choosing variants under development moldboard's working surface, and allows effectively solve the constructive problems.

2.5 Dynamic model of working surface's directory curve

The author developed a geometric model for giving directory curve of working surface and implemented in *AutoCAD 2012* and *SIMPLEX* systems. It was found that *SIMPLEX* system has some advantage over *AutoCAD* in solving constructive geometric modeling problems [17]. Unlike *AutoCAD*, where the giving process of directory curve automated only for ellipse and circles, in *SIMPLEX* process of giving automated for any conics and Bezier curves, by the same conditions. In addition, unlike the dynamic block developed in *AutoCAD*, the dynamic model in *SIMPLEX* will not only automate the process of changing the curve parameters, but also the process of determining the projection of the guide in a different position for cylindrical surface, and in case of a cylindroidal surface will determine them as template lines in each section.

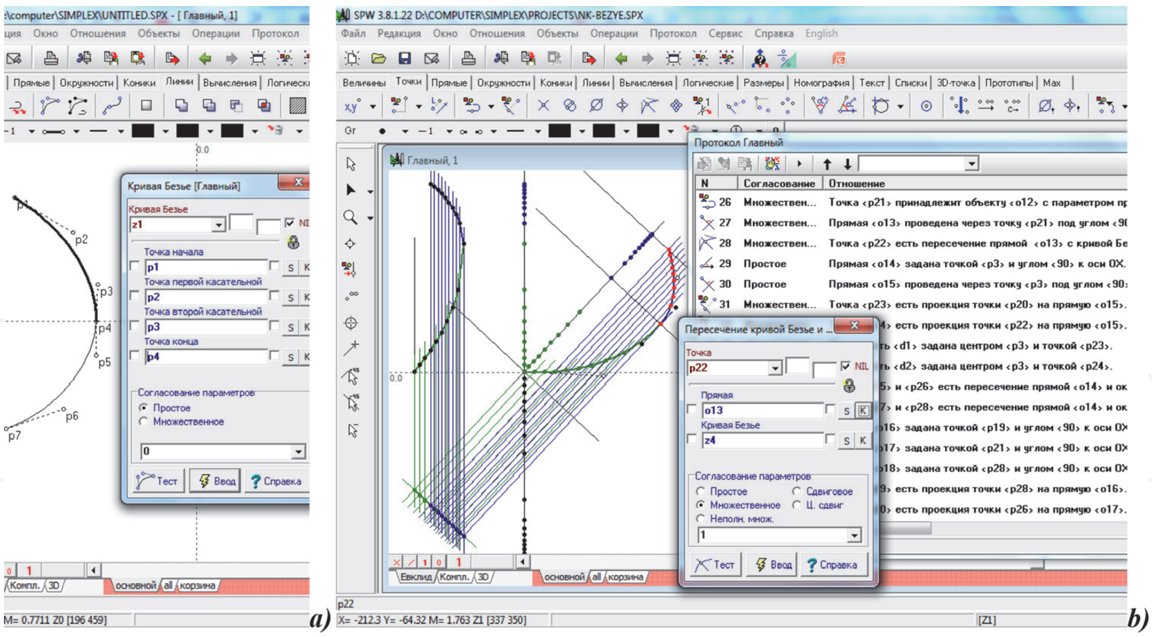


Figure 9.
Bezier curve by forward given conditions (a) and determining it's projections by multiple agreement points (b).

The plane of curve is vertical and at an angle γ_0 to the axis OX, as to the wall of the furrow. The horizontal projection of curve defines as a segment, equal to the length of L. Aligning the curve plane with horizontal plane, gives natural dimensions of curve in the plan. For easy control of curve, it can be set even by two Bezier curves. In this case, the tangent to the intermediate point P_4, is tangential simultaneously to the two Bezier curves $P_1P_2P_3P_4$ and $P_4P_5P_6P_7$ (**Figure 9a**). Determine the position of points P_1, P_4, and P_7 on the horizontal projection. Determine the frontal projections of these points by *interactive incidence* at surface formatives' heights h_0, h_i, and h_{max}. To determine the frontal projection, use the possibility of the system "*belonging to the point of the curve in multiple agreement*". In this case, this alignment can be set on a horizontal projection or on a projection in the plan. Next, the projection links determine the frontal projection (**Figure 9b**).

3. Screening the concept selecting process of Plow's moldboard model for design engineering and manufacturing

As noted in the introduction, current temps of manufacturing require development and implementation of innovative design technologies such as industrial design. The key role in this are played design engineers, because that solution of issues such energy and resource saving, increase functionality and productivity, as well as manufacturability largely depend on the technical means developed by them [3]. Studies show that use of industrial design as a powerful weapon of design engineers can give significant results in development of technical means according to various criteria, which is an applied aspect of geometric modeling [4, 18–20]. The application industrial design in this process requires the identification of tasks, the solutions of which are associated with its basis, that is, with geometric modeling [2].

The result of application industrial design in development of technical objects is their "design-project" [2, 3]. Design-project as a method of non-experimental design allows to develop technical objects with the least amount of time, labor, and money which spend in this process [18]. Therefore, the purpose of this design-project is application of research results on geometric modeling of plow's moldboard and its surface, for their further adaptation into manufacturing. Therefore, one of final results of research is the development of design-project of plug's moldboard, prepared on the basis of developed geometric models, algorithms, and methods by non-traditional design. It can highlight the following stages of design-project:

1. Analysis, evaluation, and model selection for design-project;

2. Development of the concepts and models for design-project;

3. Preparation description and sketch of proposed design;

4. Geometric modeling of the proposed design;

5. Computer simulation of the proposed design;

6. Patenting design-project for manufacturing by design conditions; and

7. Adaptation design-project for manufacturing by design conditions.

As an example, let us take a look at the design-project of plow's moldboard. At it is known, plows used in agricultural production have different design models of their moldboards according to their purpose. Each design models has its own advantage, the isomorphic application of which in another design can lead to some loss of perfection of this design. In such cases, it is possible to combine the advantages of considered models, according to various evaluation criteria, into one new design, with the necessary changes, on one of basis methods of industrial design–"*Concept selection*" [2, 20].

Moldboards have a complicated technical form, centuries-old changes to improve their designs and have a universal geometric model. These factors allow the application industrial design in the development of moldboard by geometric characteristics that affect to their technical/technological characteristics. Let us consider directions of plow's moldboard improvement.

Classic plows, having a one side turnover moldboard with cylindroidal working surface, have common use in agricultural production. Therefore, they will be considered as basic model, as it is chosen by experts as basis for development of other moldboards' design. They have good crumbling and turning indices, but these advantages are opposed to their shortcomings, which led to three improvement direction. Firstly, low manufacturability of such cases with non-sweep working surface led to development geometrically combined working surfaces [10]. Secondly, use of one side turning moldboard will lead to formation of furrows and ridges, that is, roughness of plow, which led to development vertical reversible plow. They differ in higher productivity and quality of performed works which are not demanding additional presuming agro technical actions after their using. But presence of double (right and left turning) moldboard makes construction more expensive, more metal quantity, and with greater traction resistance, which is its drawbacks, in contrast to its advantages [10]. This led to improvement in the third direction, that is, to development horizontal turn plows. There has development of technological scheme of plow with opportunities working in two right and left side, but with cylindrical working surface, which does not provide a satisfactory layer turnover [14, 21]. This analysis shows that the main reason for improvement and crossing point of advantages and disadvantages of considered designs is geometry of moldboard's working surface.

Based on of existing plows' design models and their research on improvement show that opportunity of creating design model consisting from combination of two or more design models is not used enough, and such design model combines their advantages and eliminates their disadvantages gives a solution to this problem. Among many works devoted to this problem, as an example, we can consider works relating to plow's design model [14], to technical complexity surfaces [15] or improvement parts of moldboard [11, 12]. Development was conduct on the main types of plow's moldboard design models, which takes into account several basic criteria for choice design model by geometric characteristics of moldboards, according to requirements of manufacturers and consumers [4, 9–12, 14] (**Table 4**). Among the evaluation criterions of plow, depending on its geometric parameters, it is possible to note metal quantity of construction, manufacturability of moldboard, as well as functional working quality [10]. But to combine all these quality characteristics together is problematic, because design model of moldboard has complexity geometric parameters. Production design is application of geometric modeling, and this problem can be resolve by geometric modeling.

Evaluation of criterions produced on relative to basic design model "***A***" (**Table 5**). Geometric characteristics are evaluated by their advantages (+) and disadvantages (−). The characteristics of design models that are clearly not distinguished by experts as advantages or disadvantages are conditionally evaluated neutrally (0), for reasons that they do not particularly affect to choice the design model.

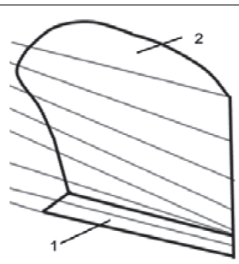
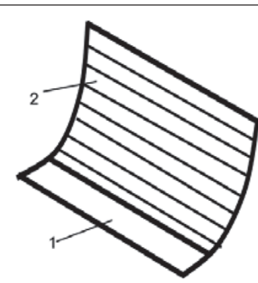
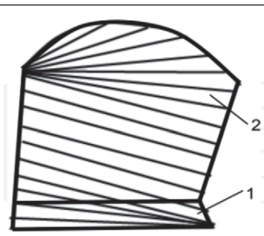
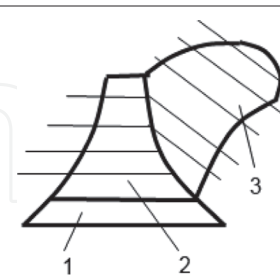
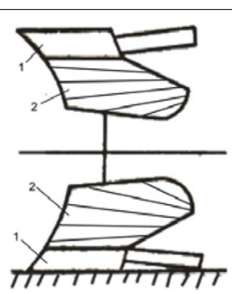
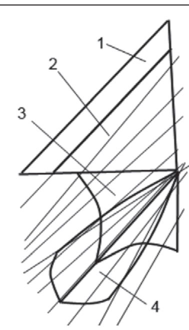
Basic design model "A"		**Revised design model "D"**	
	*For one side turning plow.* Moldboard type—classic body. Working surface—cylindroidal. *Plowshare (1), Moldboard (2).*		*For horizontal turn plow.* Moldboard type—double action body. Working surface–cylindrical. *Plowshare (1), Moldboard (2).*
Revised design model "B"		**Revised design model "E"**	
	*Plow for one side turning.* Moldboard type—experimental body. Working surface—geometrical combined. *Plowshare (1), Moldboard (2).*		*Plow for one side turning.* Moldboard type—partial body. Working surface—geometrical combined. *Plowshare (1), breast (2), wing(3).*
Revised design model "C"		**Revised design model "F"**	
	*For vertical revolving plow.* Moldboard type—doubled right and left turn body. Working surface—cylindroidal. *Plowshare (1), Moldboard (2).*		*For horizontal turn plow.* Moldboard type—partial body. Working surface—geometrical combined. *Plowshare (1), breast (2), right (3) and left (4) wings.*

Table 4.
Visual analyzing the designs of reviewed moldboard's models.

No.	Influence geometry of moldboards to technical and technological characteristics	Design models of moldboards						
		A	**B**	**C**	**D**	**E**	**F**	**G1–G3**
1	Influence to trajectory of layer	0	+	0	–	0	0	**B**
2	Influence to material quantity of plow	+	+	–	0	+	–	**BE**
3	Influence to operation quality of plowing	0	+	0	–	0	0	**B**
4	Influence to smoothness of plow	–	–	+	+	–	+	**CDF**
5	Influence to functionality of plow	–	–	–	–	+	+	**EF**
6	Influence to manufacturability of moldboard	–	–	–	+	0	0	**D**
7	Influence to complexity of moldboard design	+	+	0	0	0	–	**B**
8	Amount of disadvantages "–"	Basic	3	3	3	1	2	Proposed
9	Amount of advantages "+"		4	1	2	2	2	
10	Summarized amount		1	–2	1–	1	0	
11	Rating placement		1	4	3	1	2	

Table 5.
Evaluation the moldboards' criterions by geometric characteristics.

Material quantity and complexity of design model "***A***" has advantages, but it does not provide smooth plowing and its cylindroidal surface is low technologically for manufacturing. The functionality of this design model is also low, as it is developed for individual agricultural conditions. Therefore, its shortcomings have led to the development of new designs aimed at their elimination. Geometrically combined working surface design model "B" of experimental moldboard allows good control of layer trajectory and quality of processing. Other qualities of design model "***B***" are approximately the same with design model "***A***." They are not widely used, because their working surface has geometric complexity for giving by manufacturers. Design model "***C***" of vertical revolving plow's moldboard is the same as design model "***A***.". Its advantages and disadvantages are associated with design of itself. Therefore, they are widely used. Design model "***D***" of horizontal turn plow's moldboard provides smooth plowing, its cylindrical surface is simply for manufacturing. However, its surface worse controls layer trajectory and poorly turnover it. Information about their use in conditions of Uzbekistan is not available. Design model "***E***" of moldboard, although not widely used, its main advantage is multifunctionality, as replacement of its wings allows us to adopt it to different agricultural conditions. However, it is intended for one side operation. Design model "***F***" of horizontal turn plow's moldboard has advantages such as multifunctionality and double-acting possibility, but it is very complexity and material quantity [22].

Visualization of qualitative assessment and analysis of characteristics in this way allows us to choose direction of design modeling on advantages, by combination of design models. However, although the development of a model based on the principle of "*Concept selection*" is initial stage of design and is subject to further development, it reduces above-mentioned design costs.

Next stage of development will be produce by design models that took 1–3 places on the rating of evaluation criteria. Variants of proposed design models "***G1***", "***G2***", "***G3***" of moldboards (**Table 6**), taking into account advantages of considered design models, have geometrically combined working surface, they consist separate parts and they have double-acting opportunity. On base of improved models analyzing and in results of studies, finally we can offer new geometric modeling direction (proposed direction "***G***") for improving models (**Figure 10**).

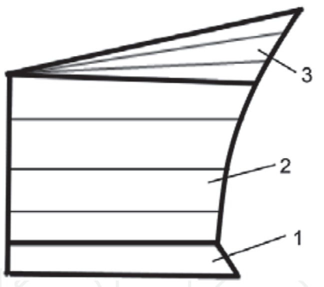
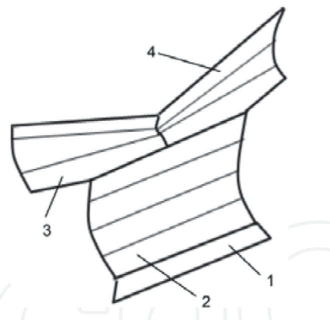
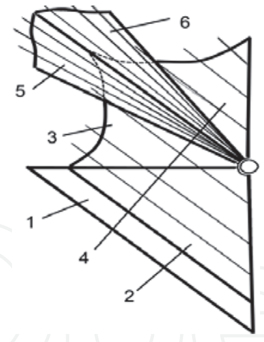
Proposed model G1 by B and D	Proposed model G2 by B and E	Proposed model G3 by B and F
		
Plow for one side turning. Moldboard type–partial body. Working surface—geometrical combined. Plowshare (1), breast (2), wing (3).	For horizontal turn plow. Moldboard type–partial body. Working surface—geometrical combined. Plowshare (1), breast (2), right (3) and left (4) wings.	For horizontal turn plow. Moldboard type–partial body. Working surface—geometrical combined. Plowshare (1), main breast (2), right (3) and left (4) ancillary breast, right (5) and left (6) wings.

Table 6.
Description the design of proposed moldboard's models.

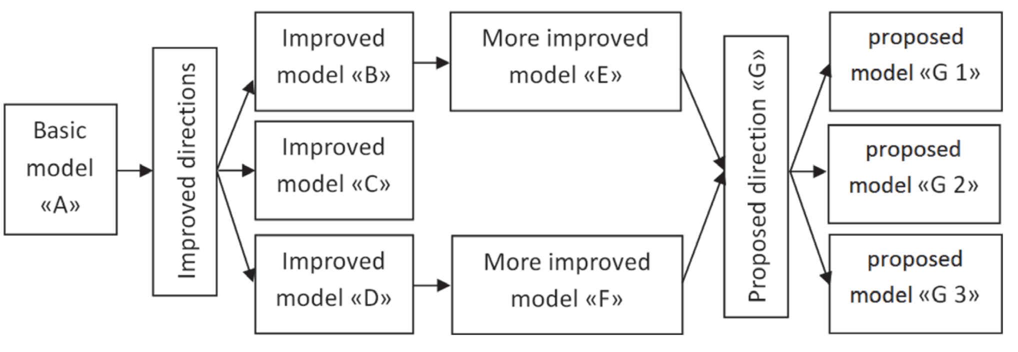


Figure 10.
Improving and proposing the moldboard designing directions.

4. Determining the integrative role of geometric modeling in tools' PLM for manufacturing

Modern manufacturing is base on CALS-technology (Continuous Acquisition and Lifecycle Support) or PLM-technology (information support of the product lifecycle management processes) by use the information science and communication technologies. PLM is an approach to design engineering and manufacturing high-tech and scientifically based product, concluding in use the information science and computer technology on all stages of the product lifecycle [23].

This aspect is actual in condition of developing countries like Uzbekistan, where using these technologies in manufacturing is considering as innovative process. One of the problems of this process is adaptation of these technologies on manufacturing, that is, transfer of engineering data into the PLM system, by integrating it with CAD/CAE/CAM systems, using the product's engineering database on base of PDM-technology (product data management).

The product's engineering data can be divided into three groups: constructive, functional, and technological. Let us consider the constructive data, which can be call also geometric data, that is necessary for the integration CAD and PDM

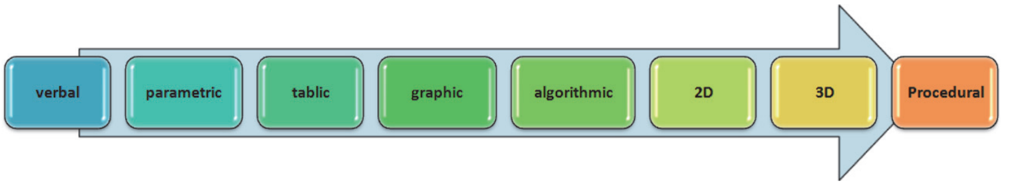


Figure 11.
Types and levels of geometric data information for design engineering.

systems. The product's geometric data is used not only in the company where it is produced, but also at all stages of product lifecycle from designing to manufacturing and post-manufacturing. Therefore creating the geometric database, which consist from the using different forms of geometric data (**Figure 11**), is very important in product lifecycle.

Product lifecycle includes period from origin necessity for creating the product up to its liquidations in consequence exhaustion of consumer characteristic. Primary stages of product lifecycle are selecting four main stages: designing, manufacturing, technical exploiting, and utilizing.

Though lifecycles of old and new product always formed unceasing cycle, because of not bright images, traditional lifecycles of each product were considered separately; whose initial stage is a designing but final salvaging. However, author founding on his conducting researches, offers to consider that beginning of PLM from creation an instrument from stone, bones, and wood by primitive man. Today someone cannot reject that base of modern industrial robot is an instruments of the stone age, so the end of "old" product is a beginning of "new" product. The present production conditions, in which production design steel is playing one of solving roles, relationship between "old" and "new" products in their lifecycle become reveals itself all more brighter. Coming from author offers separate stage of the designing on two: conceptual and engineering design. The conceptual design stage is based on the geometric modeling and it is closing stage of the product lifecycle having causal relationship between "post-manufacturing" (maintenance-utilizing) and "designing" stages. In current manufacturing conditions, geometric modeling has become the primary method and facility of the designing. At this stage, the product will designed on base of the relationships between exhaustion of consumer properties of an old product and necessity to creation a new (innovative) product.

The need for geometric data is at all stages of the life cycle of the product, especially at the initial stage, at the stage of "conceptual design". The Geometric Database created at this stage is directly or indirectly applied and at the subsequent stages of the product lifecycle, by integration CAD and PDM systems. It is necessary to note requirement to create "new product" basically it is formed in maintenance step of "old" product. Because at this stage, it is not only the Geometric data of "old" product in maintenance but also arises Geometric Data of "new" product in designing.

For example, let us consider the creation of Geometric Database in agriculture engineering tools manufacturing, which are necessary for enterprises participating in their products lifecycle [19, 23–26]. Creating this Database requires review, classification, and analysis of relevant information about agricultural machinery tools from geometric standpoint. This will enable us to identify the general and individual geometric features of these tools which will assists all participants in the lifecycle of data management in this process (**Figure 12**). The author is currently conducting research on the development of theoretical foundations and practical aspects of geometric modeling of agricultural machinery tools. Based on the results of the research models, algorithms and methods of designing these tools with moldboard surface by geometric modeling have been developed.

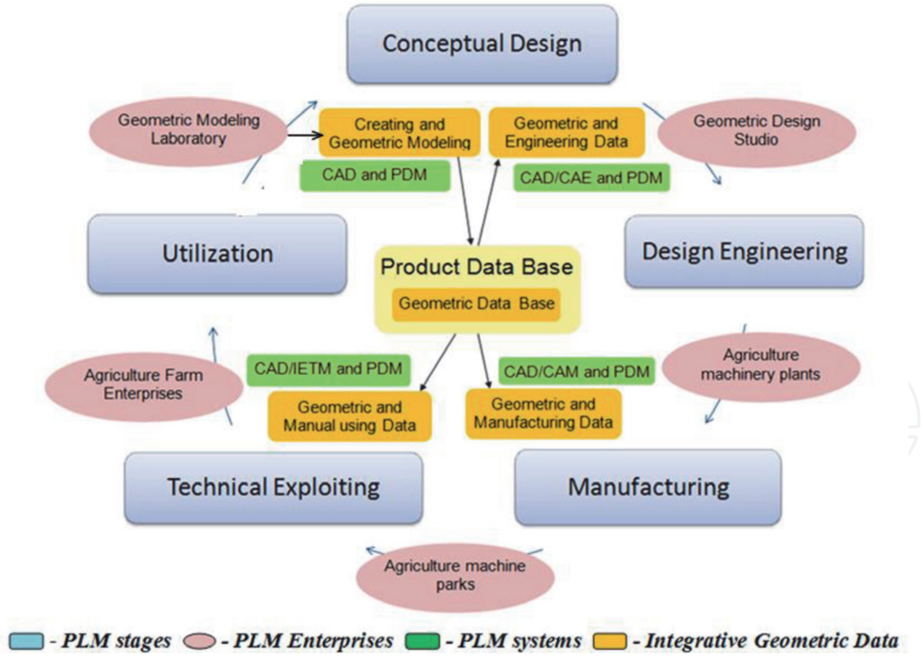


Figure 12.
Integration role of geometric modeling methods and systems in PLM.

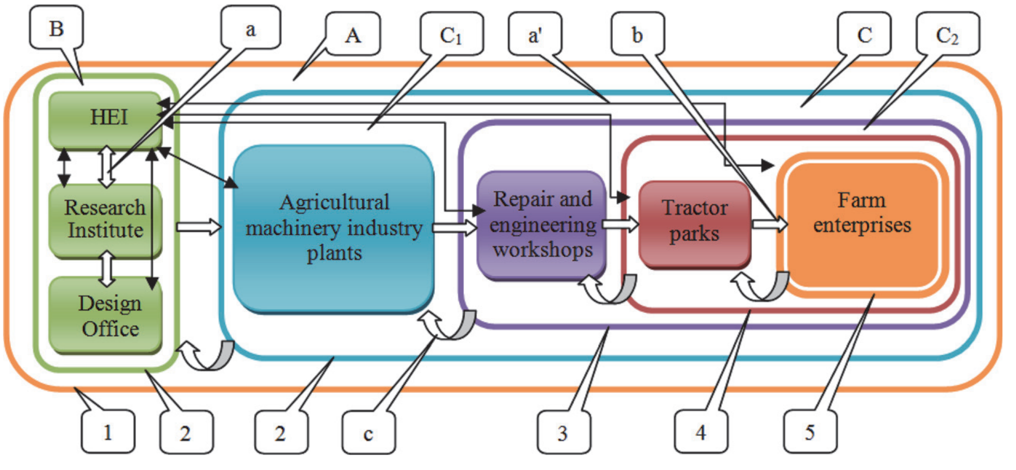


Figure 13.
Design engineering cluster's framework in agriculture.

As a result, sufficient information was collected to create a geometric database in different forms. It is possible to allocate following forms of the geometrical (graphic) data (information): verbal, graphical, parametric, algorithmic, 2D and 3D model, procedural.

Procedural data as manual using data can include all forms of geometric data. On base of research results, author worked out project-model of "Innovation cluster for design engineering and manufacturing in Agriculture engineering," when geometric modeling methods, applications, and systems play one of basic role (**Figure 13**). Framework of innovative cluster developed by system analyze of design engineering and manufacturing in Agriculture machinery tools PLM on view point of geometric modeling. In this cluster:

1. System framework: Over system ***A***–*"Government"*; Systems ***B***–*"University"* and ***C***–*"Industry"*; Subsystems ***C1***–*"Producer"* and ***C2***–*"Customer"*; Offered subsystem ***B***′–*"Innovative cluster on designing in agricultural machinery industry"*;

2. System components: ***B1***–*"Jurisdictional HEI (Higher Educational Institutions)"*, ***B2***–*"Jurisdictional Research Institutes"*, ***B3***–*"Jurisdictional Design Offices"*, ***C1***–*"Agricultural machinery industry plants"*, ***C21***–*"Repair and engineering workshops"*, ***C22***–*"Tractor parks"*, ***C23***–*"Farm enterprises"*. Offered component ***B1′***–*"Design office on geometric modeling"*;

3. System levels: ***1***-*National,* ***2***-*Regional,* ***3***-*Sub regional,* ***4***-*District, and* ***5***-*Sub district*;

4. System connections between components along cluster ***B′***: ***a***–inside system connections along designing the project, ***b***–consecutive outside (***output***) connections for implementation the project, ***c***–reverse outside (***input***) connections for correction the project;

5. ***a′*** - functional connections of component ***B1′*** with other components along cluster ***B′***;

5. Conclusions

The proposed constructive geometric model of moldboard's working surface, allows to develop the multifunctional tools applicable in agricultural engineering, road building, mining, municipal service, and others branches of machinery. Parameterization of the moldboard's working surface facilitates the designer's work, expands the options for choosing the under developing moldboard's working surface and allows effectively to solve the constructive problems. The integration role of geometric modeling methods, systems, and applications allows efficiently apply them not only in design engineering process, and also in manufacturing processes of technical means. Creating the product's geometric database by CAD technologies became one of the necessary tasks of manufacturing, particularly engineering products. In contemporary conditions of using CALS technologies, "conceptual design" stage of innovative product by methods and facilities of geometric modeling is defining stage of the product lifecycle. So this application has signification in PLM, because geometric data will apply in all stages of PLM by geometric modeling methods, applications, and systems. The visualization of design-project process allows to develop the new production according to designing, manufacturing, and maintenance criterions. Effective use of these methods allows to reduce terms, labor, and material expenses of design process of new product. All figures and tables are produced by the author. All chapter materials are results of author researches, conducting in doctoral studies period by sponsorships of Government of the Republic of Uzbekistan in the Tashkent Institute of Irrigation and Agriculture Mechanization Engineers and Bukhara Institute of Engineering Technology [27].

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References

[1] Edict of the President of the Republic of Uzbekistan. About strategies actions on the further development of the Republic of Uzbekistan. Tashkent. Newspaper "Xalq so'zi", No. 28 (6692), February 8, 2017

[2] Production design. Principles, tools and techniques. ME 1007 design principles. Concept selection. Available from: http://www.product_design_principles.pdf

[3] Tyalve E. Short Course of the Industrial Design. Translation by Kunin PA. Moscow: Mashinostroenie; 1984. 192 p

[4] Juraev TX. Geometrical Modeling Principles of Meliorative and Agriculture Machines Tools. Monograph. Saarbrucken: Lambert Academic Publishing; 2015. ISBN 978-3-659-66832-6. Available from: http://dnb.d-nb.de

[5] Voloshinov DV. Theory of automation of design of objects and processes on the basis of methods of constructive geometric modeling: Annotation of Dissertation: SPb.: SPbSPU, 2010. 33 p

[6] Goryachkin VP. Collected Works. Vol. 1–2. Moscow: Kolos; 1965 648 p

[7] Korabelski VI. Justification of the shape and parameters tillage bodies using geometrical modeling of the main technological requirements [thesis of dissertation]. Chelyabinsk: ChIMEA; 1988. 450 p

[8] Gyachev LV. Theory of Share-Moldboard Surface. Zernograd: Gosgortekhizdat; 1961. 317 p

[9] Shestopalov KK. Machines for Earthworks: School-Book. Moscow: MADI; 2011. 145 p

[10] Bosoy EC et al. The Theory, Design and Engineering of the Agricultural Machines. Moscow: Mashinostroenie; 1978. 568 p

[11] Mould boards. Available from: http://www.max-agro.ru

[12] Catalogue of special machines. ISP GROUP. Available from: www.isp-group.ru

[13] Voloshinov DV. The Theory to automations of the designing object and processes on base of the methods of constructive geometric modeling [abstract of DSc thesis] Saint-Petersburg; 2010

[14] Biliev AA. The motivation of the technological scheme of the plow for smooth two-tier plowing [abstract of PhD thesis]. Moscow. VIM; 1992. 22 p

[15] Dubanov AA. Methods and algorithms to approximations of the technical surfaces turning round [abstract of PhD thesis]. Moscow. MUPP; 1997

[16] Murodov SK et al. Descriptive Geometry. School-Book. Tashkent: IQTISOD-MOLIYA; 2008

[17] Voloshinov DV. Constructive Geometric Modeling. Theory, Application, Automatization: Monograph. Saarbrucken: Lambert Academic Publishing; 2010. 355 p

[18] Kobec AS, Sokol SP, Korabelski VI, Naumenko NN, Kobec AN. Design-project shape geometry of formative alternating curved surface of bracket. Available from: http://www.nbuv.gov.ua

[19] Juraev TX. Creating the Geometric Database for Product Lifecycle Management System in Agricultural Engineering. International Conference on Information Science and Communications Technologies ICISCT

2017 Applications, Trends and Opportunities. 2–4 November 2017; TUIT, Tashkent, Uzbekistan. IEEE Catalog Part Number: CFP17H74-CDR, ISBN: 978-1-5386-2167-7. Available from: https://www.researchgate.net/publication/321821311

[20] Juraev TX. Conceptual designing of mould board's surface by geometrical modeling. American Journal of Mechanics and Applications. 2017;**5**(4): 28-33. DOI: 10.11648/j.ajma.20170504.11. ISSN: 2376-6115 (Print); ISSN: 2376-6131 (Online). Available from: http://www.ajmechanics.org/archive/621/6210504

[21] Flat plowing plow. SU1732826 (A1)-1992-05-15 Available from: http://www.Espasenet

[22] Juraev TX. Decision maintenance management problems in agriculture engineering by constructive geometric modeling methods. Maintenance Management. DOI: 10.5772 / IntechOpen.81969

[23] Jayakiran Reddy E, Venkatachalapathia N, Pandu Rangadu V. Development of an approach for knowledge-based system for CAD modeling. Selection and/or peer-review under responsibility of international conference on materials manufacturing and modeling (ICMMM-2017). Science direct. Materials Today: Proceedings. 2018;**5**:13375-13382

[24] Juraev TX. Geometric modeling for organizing innovative cluster on designing in agricultural machinery industry. Proceedings of the international conference on integrated innovative development of Zarafshan region: achievements, challenges and prospects. Vol. II. 26–27 October, 2017. Navoi, Uzbekistan: NSMI. pp. 248-251

[25] Juraev TX. Geometrical modeling of agricultural machines as a mean of engineering provision of agriculture production. The collection materials of VIII-th International scientific conference "Modern technologies in agricultural production and education." Kemerovo, Russia: KSIA. 2017. Available from: http://www.ksai.ru/upload/files/sborniki/inyaz_2017/files/assets/basic-html/page119.html

[26] Matejun M. The process of opportunities exploration and exploitation in the development of SMEs' innovativeness. Management and Production Engineering Review. 2018; **9**(3):3-15. DOI: 10.24425/119529

[27] Juraev TX. Geometric modeling of agriculture and meliorative machines' tools [abstract of PhD dissertation]. Tashkent University of Information Technologies; 2019. Available from: www.tuit.uz