BODY AND SYSTEM GENERATION METHOD FOR MECHANICAL CONSTRUCTIONS

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Abstract : Typosize multitude for the parts which compose different subassemblies, devices, equipments and machines from the most simple up to complex systems are constituted of primitive geometrical bodies assembled in a certain mode determined by morphofunctional necessities.

Within the mechanical engineering, the modernization of the production processes and equipments pressumes the optimalization to obtain raw materials, new processing methods, the realization of devices, tools, equipments and performance machines with high accuracy and productivity obtained within of some fabrication complexe systems which can be configurate and reconfigurate easily depending on the production target characteristics.

The modern industry characterized by the assimilation of new products in a sustained rhythm involves to find some solutions to realize the parts with forms, complex functions but and with high accuracy, which to allow the utilization of the mathematical modelling as a body and system generation method for mechanical constructions. The method proposed starts from the concept that the geometrical primitives (straight line segment, circles, polygons, conics, cube, parallelepiped etc.) are those base elements which the programme written in VB (Visual Basic) can use its to realize the drawings necessarily to some technical applications.

The realization of these applications are based on connexion between the primitive bodies described by specific equations, using the theory of contact transformations and booleene operations, but in the case of the devices and equipment construction was solved the structures emplacement on the base plate using a configuration algorithm.

INTRODUCTION

The application of the body and system generation method to construct a modular device, allows that all modular components in it construction to be configurated and emplaced adequately on the base plate, so that between these to exist a sufficient space so that the operator and tools to have the acces into the working zone. The utilization of the application gives the possibility to verify all that created and it can realize a better productivity.

BI-DIMENSIONAL AND THREE-DIMENSIONAL BODY CONSTRUCTION GEOMETRY

Geometrical primitives (points, straight line segments, rectangles, polygons, conics, cuadrics, cubes, parallelepipeds etc.) are those base elements which the programmer can use its to realize the drawings necessarily to some technical applications. Primitive geometrical forms are well defined into the coordinate system. This thing allows to establish a geometrical body basic named, confronted by which it makes the reference to the other geometrical bodies, so that to result the structure of the part using connexion rules between its.

The working hypothesis are the following :
- The raw part (obtained by casting, forging, moulding), the finished part (obtained by chipping)   is considered as a body of **m** mass which may be divided in elementary volumes ;
- By the architecture of a body it understands a part essembly, named geometrical bodies, found into a well defined relation ;
- The general form of the part (body) may be decomposed in three-dimensional geometrical forms which are
subordinated to the composition laws which characterize the body taken as an unitary whole.
- To the geometrical forms may applied the plane or space geometrical transformations.

- To the geometrical forms may applied the booleene operations.
- To the geometrical forms may applied the contact transformations.

BI-DIMENSIONAL TRANSFORMATIONS

Being aquainted with the fact that the geometrical transformations are functions [1], it considers a cartesian reference, a bi-dimensional object described confronted by this reference system and Q (x,y) a certain point of the object.

• TRANSLATION

We consider the reference cartesian system, x, y the coordinates of the point Q and   the equations   which define a plane transformations x´=f(x,y), y´=g(x,y) which allow the passing from the point Q(x,y) to Q´(x´,y´).
The transformation equations are :
$$x' = x + \Delta x \quad \text{and} \quad y' = y + \Delta y \tag{1}$$
where : Δx and Δy are the specific displacements.
The matrix product which allows the translation is :

$$\begin{pmatrix} x & y & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 1 \\ \Delta x & \Delta y & 0 \end{pmatrix} = \begin{pmatrix} x+\Delta x & y+\Delta y & 1 \end{pmatrix} = \begin{pmatrix} x' & y' & 1 \end{pmatrix} \tag{2}$$
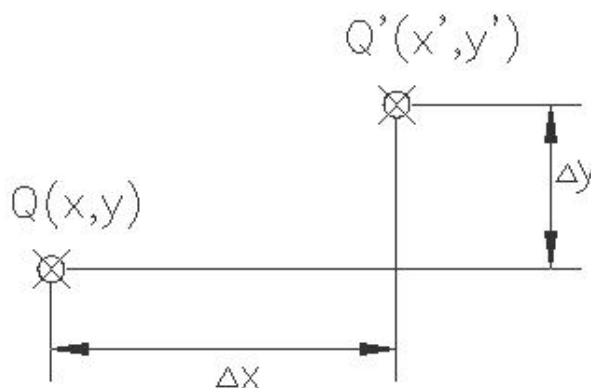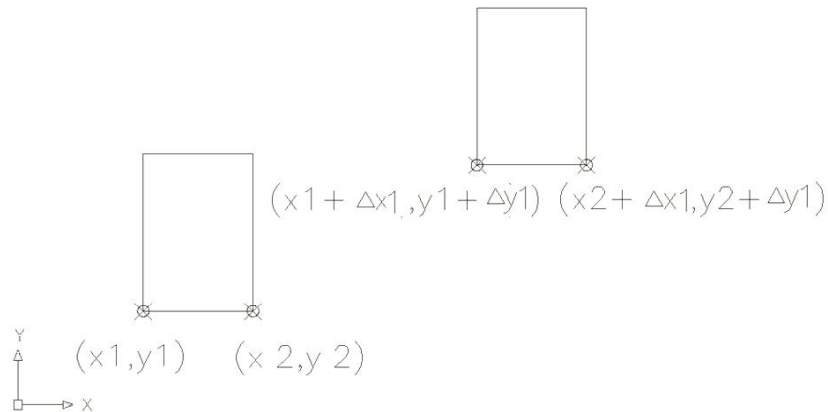

Figure 1. Translation of a point

Figure 2. Translation of a plane figure

- **SCALING**

The transformation equations are :

$$x' = s_x \cdot x \quad \text{şi} \quad y' = sy \cdot y \tag{3}$$

where : s_x, s_y are scaling constants.
The matrix product which allows the scaling is :

$$\begin{pmatrix} x & y & 1 \end{pmatrix} \cdot \begin{pmatrix} s_x & 0 & 0 \\ 0 & s_y & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} s_x \cdot x & s_y \cdot y & 1 \end{pmatrix} = \begin{pmatrix} x' & y' & 1 \end{pmatrix} \tag{4}$$
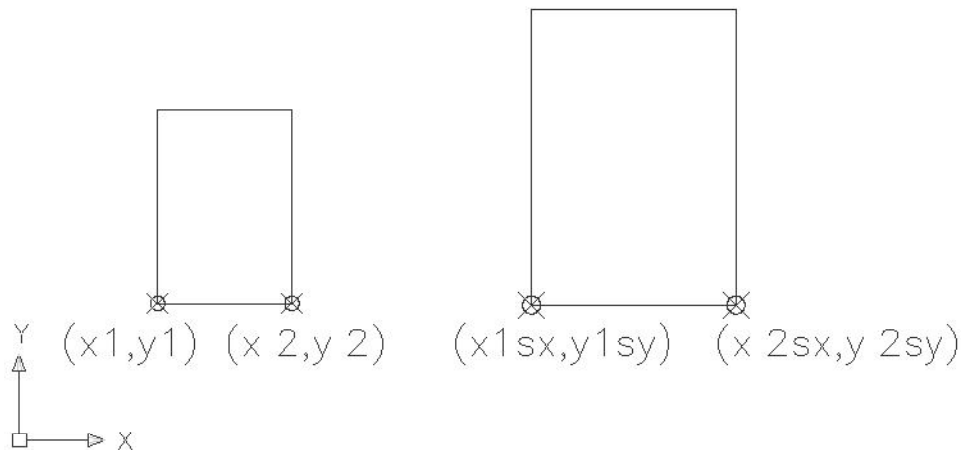

Figure 3. Scaling of a plane figure

- **ROTATION**

To be θ the rotation angle around of the coordinate system origin, while Q a point which found at a distance r confronted by this origin and under the angle α confronted by Ox. The transformation equations are :

$$x = r \cdot \cos \alpha \ ; \ y = r \cdot \sin \alpha \tag{5}$$

$$x' = x \cdot \cos \theta - y \cdot \sin \theta \ ; \ y' = x \cdot \sin \theta + y \cdot \cos \theta$$

where : s_x, s_y are scaling constants.
The matrix product which allows the rotation, namely the coordinate of the point Q′ is :

$$(x \quad y \quad 1) \cdot \begin{pmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix} = (x' \quad y' \quad 1) \tag{6}$$

Figure 4. Rotation of a plane figure

In practice we use the composition of 2D transformations which transformation general matrix is :

$$\begin{pmatrix} A & B & 1 \\ C & D & 1 \\ \Delta x & \Delta y & 1 \end{pmatrix} \tag{7}$$

where :   A, B, C, D are parameters which give the scaling, rotation and symmetry, while the specific displacements Δx and Δy give the translation.

THREE-DIMENSIONAL TRANSFORMATIONS

 We specify that a point Q(x,y,z) is represented in the homogeneous coordinate system by the point
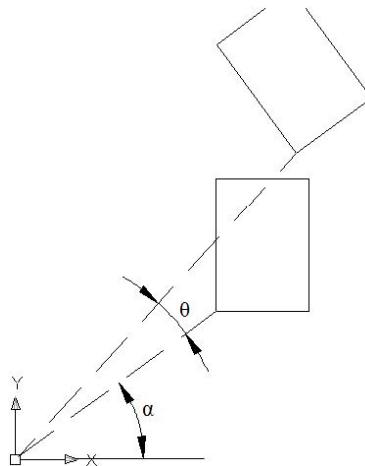 Q(x,y,z,l).

• **TRANSLATION**

  The matrix product which allows the translations is :

$$(x \quad y \quad z \quad 1) \cdot \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \Delta x & \Delta y & \Delta z & 1 \end{pmatrix} = (x+\Delta x \quad y+\Delta y \quad z+\Delta z \quad 1) = (x' \quad y' \quad z' \quad 1) \tag{8}$$

• **SCALING**

The matrix product which allows the scaling is :

$$(x \quad y \quad z \quad 1) \cdot \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ sx & sy & sz & 1 \end{pmatrix} = (x+sx \quad y+sy \quad z+sz \quad 1) = (x^{'} \quad y^{'} \quad z^{'} \quad 1) \quad (9)$$

- **ROTATION**

The transformation matrices corresponding to the rotations around the axes Oz, Oy, Ox are :

$$R_{Oz} = \begin{pmatrix} \cos\theta & \sin\theta & 0 & 0 \\ -\sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}; \quad R_{Oy} = \begin{pmatrix} \cos\theta & 0 & -\sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ \sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix};$$

$$R_{Ox} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & \sin\theta & 0 \\ 0 & -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (10)$$

We mention that the general matrix of the transformations composed 3D is the product of the elementary
transformation matrices...

BI-DIMENSIONAL FIGURE CONSTRUCTION

To realize the computer-aided bi-dimensional figure construction, its were written in VB description procedures for : straight line, circle, polygon etc. an appealing programme of these procedures to realize the composition of the complex object and then to stock the top and border coordinates into an external file of Excel type.
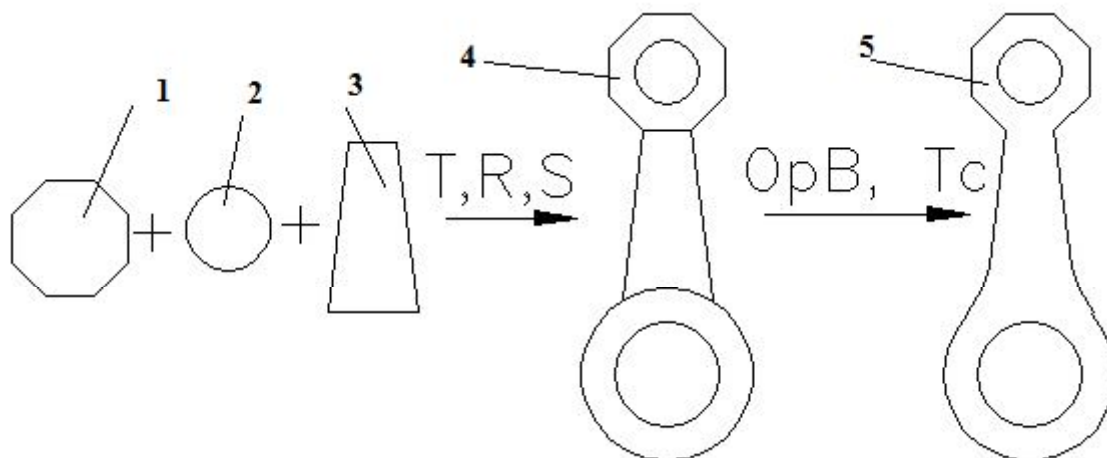

Figure 5. Generation of a plane figure.

The signification of the terms of Figure 5 are :

- T→ translation
- R→ rotation
- S→ scaling
- OpB→ booleene operations (reunion, ingtersection, reduction)
- Tc→ contact transformations

The plane figures in Figure 5 represent the components which essembled by the translation operations (T), rotation (R), scaling (S), completed by the booleene operations lead to the final form 5.

THREE-DIMENSIONAL BODY CONSTRUCTION

To realize computer-aided three-dimensional figure construction, it was written in VB description procedures for : cylinder, conics, parallelepipeds, etc., an appealling programme of these procedures, to
realize the composition of the complex object and then to stock the top and border coordinates into an external file of Excel type.
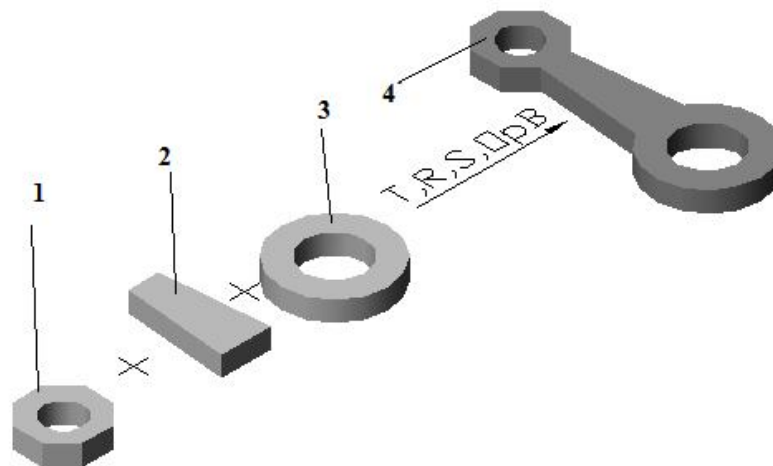

Figure 6. Generation of a three-dimensional body

The signification of the terms of Figure 6 are :
- T→ translation

- R→ rotation
- S→ scaling
- OpB→ booleene operations
- Tc→contact transformations

The bodies 1,2,3 in Figure 6 represented in three-dimensional space represent the components which essembled by the operations of translation (T), rotation (R), scaling (S), completed by the booleene operations lead to the final part 4.

PECULIARITY OF GENERATION METHODS FOR MECHANICAL SYSTEM CONSTRUCTION

To write the computer programme in VB, we have trated the peculiarity of the body and mechanical construction system generation methods for the designing range of the

technological devices. The general form of the application is presented in the Figure 7. The computer programme is similarly with a tablet and it has the following functions :
- is selected from the geometrical figure matrix a suitable form and then we draws it and delivers it in the
working zone ;
- is introduced the rotation angle ;
- are introduced the scaling sizes ;
- is selected from the geometrical figure matrix the following one and is realized the connexion with the other ;
- are applied the booleene operations (reunion, intersection and reduction), to obtain the final form ;
- is saved as into a file.
The matrix is in reality a simplified one to demonstrate the principle, in the practice, the matrix is more extended.
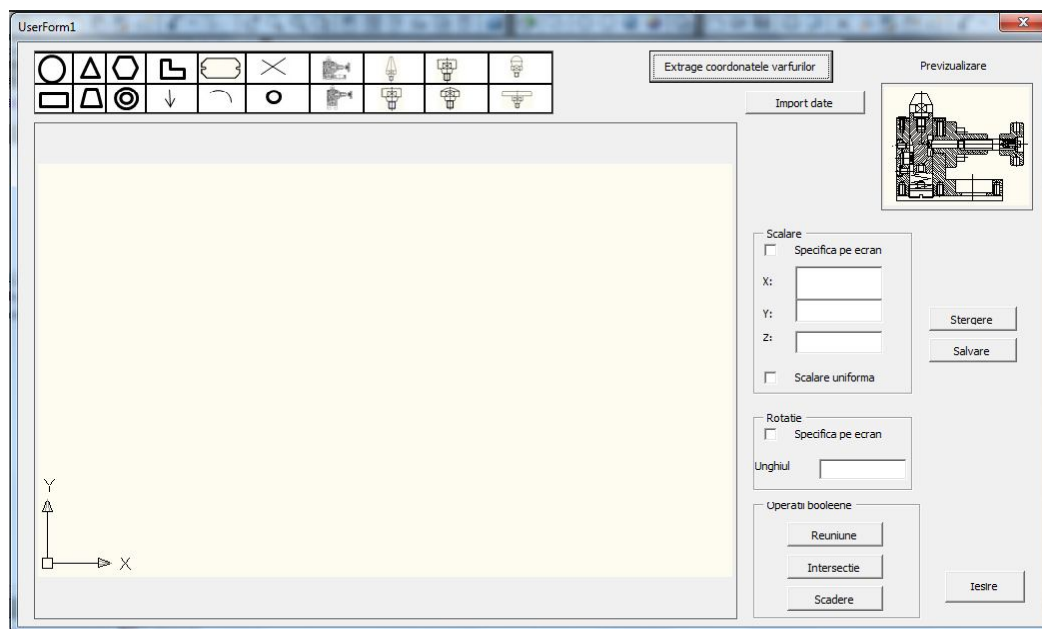

Figure 7. Application main form

By this application, we propose ourselves to obtain the drawing of an orientation and fastening device of the raw parts in Figure 8. This essembly drawing represents a relative simply mechanical system, but in the same mode it proceeds to construct and to configurate of some mechanical systems.
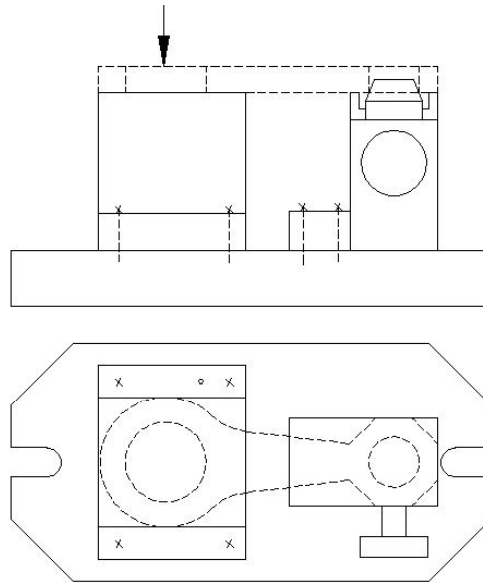
Figure 8. Drawing of an orientation and fastening device

The computer-aided designing of the device is performed in the effective realization order of the essembly drawing.

The stages are :

E01 : is represented the drawing of the raw part around of which is constructed the device presented in the Figure 9.
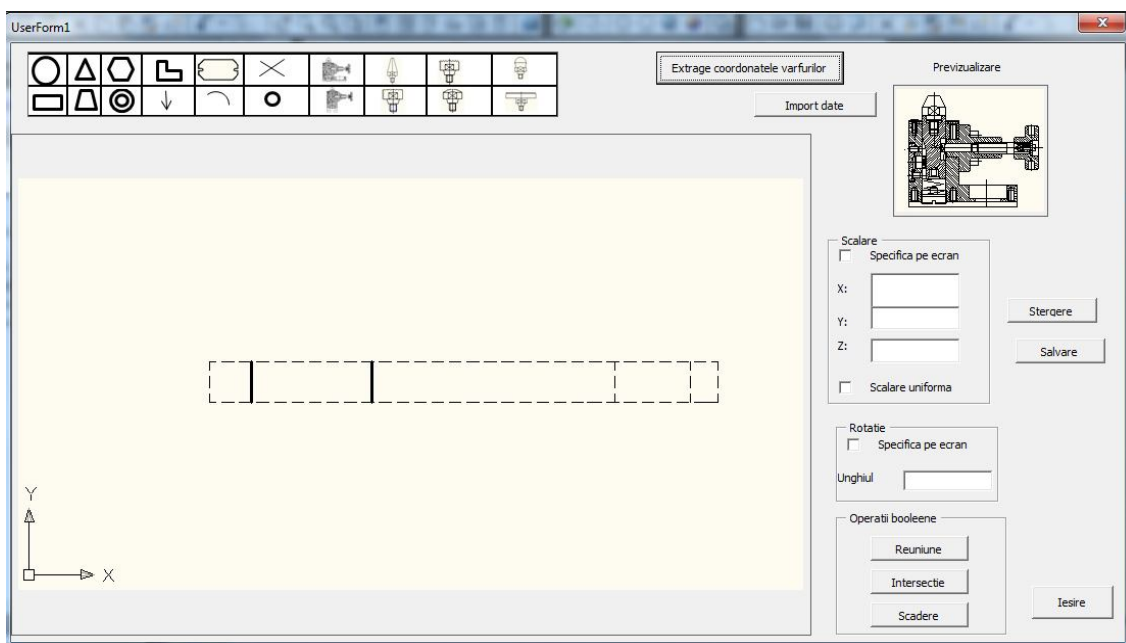

Figure 9. Raw part representation

E02 : are emplaced the support elements on the surfaces established as orientation bases of the raw part represented in the Figure 10.

The matrix is constituted of plane geometrical figures or three-dimensional bodies, but especially of subessemblies or device elements as modular structures existing in a data base or physical components stocked in a construction and mounting base of these equipments.
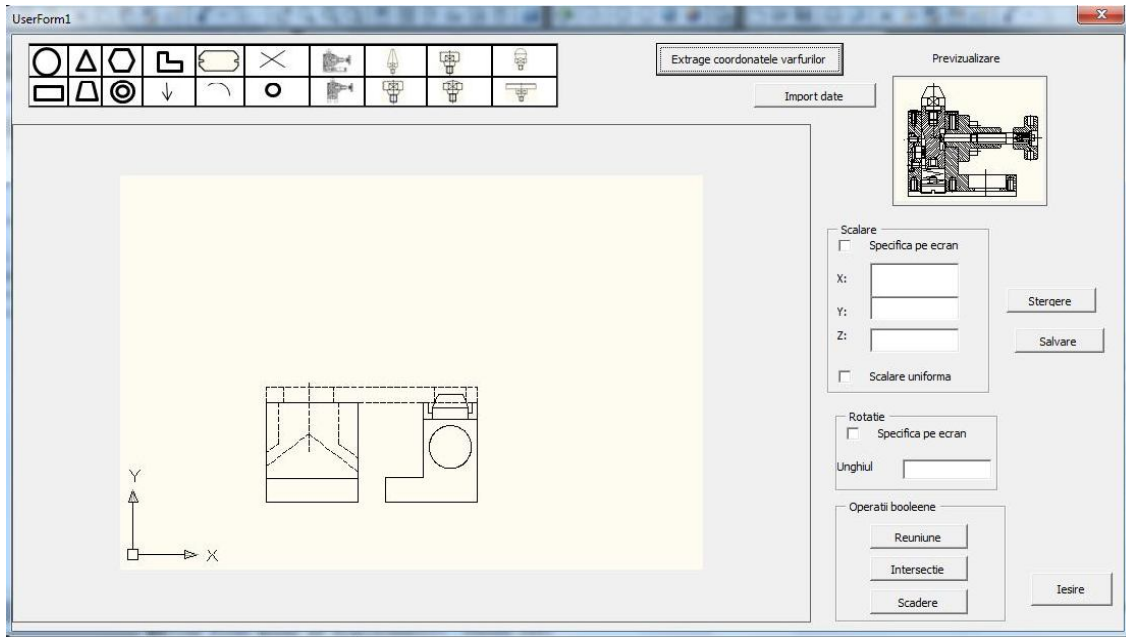
Figure 10. Orientation support emplacement of devices

E03 : is emplaced the base plate of the device presented in Figure 11.
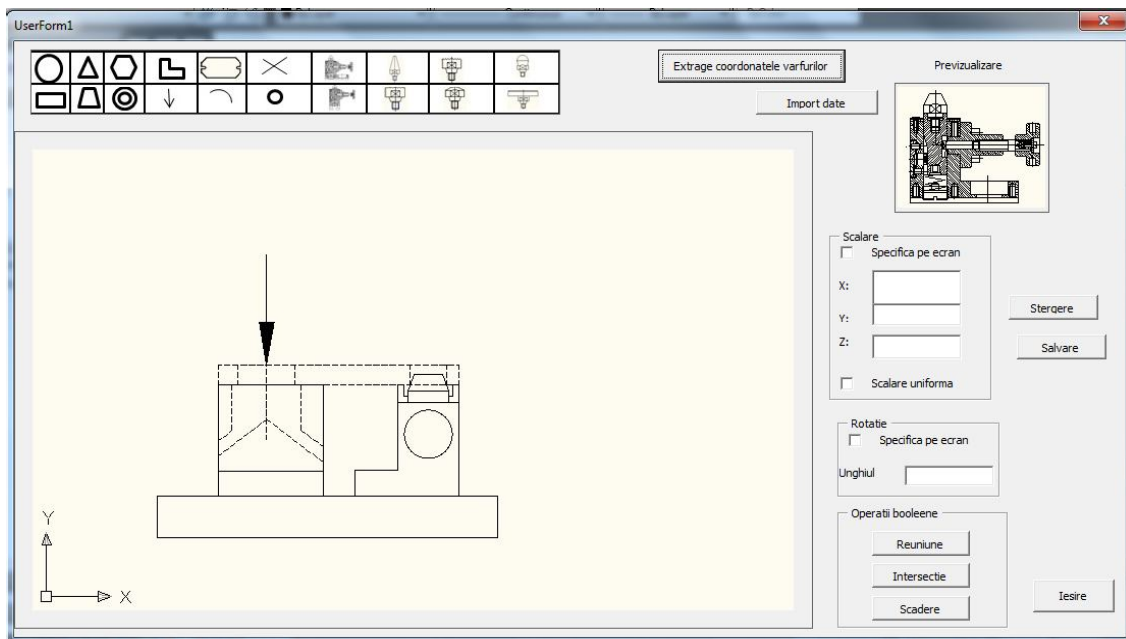E04 : is attached the fixing system represented symbolically to not complicate the drawing.

Figure 11. Emplacement of the device base plate

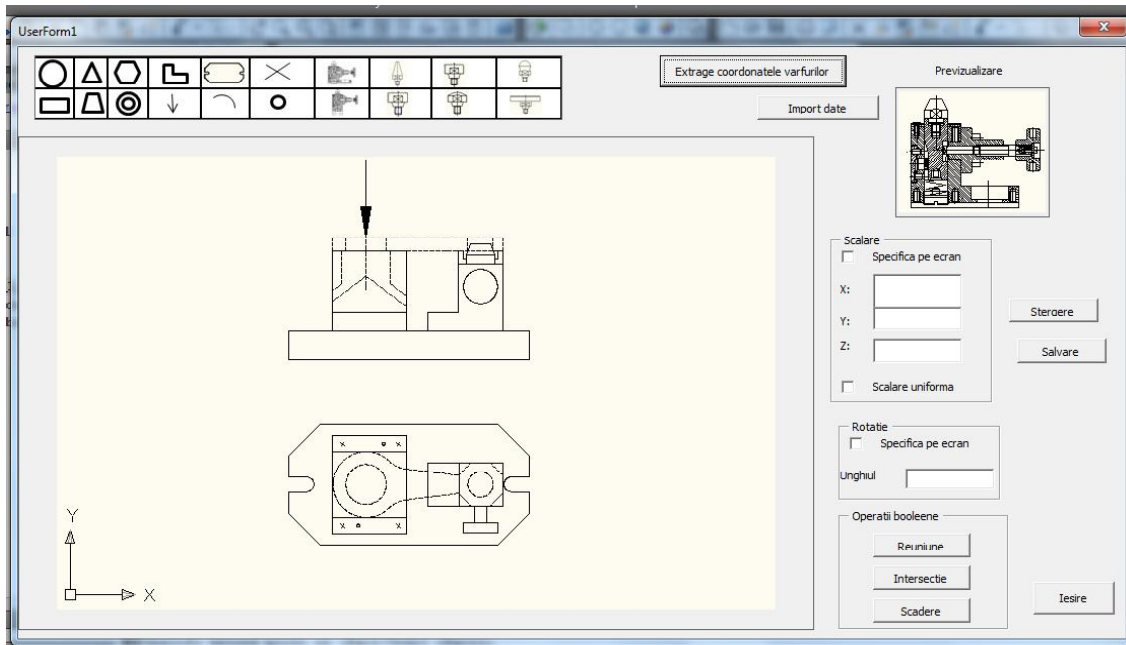In the Figure 12 is presented the essembly drawing of the device
.

Figure 12. Esembly drawing of the device

From the analysis of the essembly drawing it may draw the conclusion , in this case, that all modular components of this device are configurared and emplaced adequately on the base plate so that between of these exist a sufficient space in order to the operator and tools to have the access into the working zone.

In other situations, using the body and complex system method, it is possibly to find that some components

to interfere or to not offer sufficient spaces to emplace the component structures and the operator or tools access into the working zone. In this case, it is necessarily to intervene appealling at the scaling, reconfiguration and booleene operations to configurate suitably the device essembly or other mechanical systems.

REFERENCES

[1] Albeanu, G., *Computer graphycs*, University of Bucharest, 2001
[2] Babă A., Contriutions concerning computer-aided designing of the support elements from the organologic device system of the raw part orientation and fastening, 2009, Bucharest.