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THE SIMPLIFIED ROTATION METHOD

Abstract: *The simplified rotation method derives from the classic rotation method included in the chapter on descriptive geometry methods. This simplified method eliminates the rotation axis, being a particular case of level or front rotation methods. The omission of the rotation axis involves performing compound rotational and translational movements, successive movements, until the studied element occupies a convenient position in space, relative to the projection planes, which allows the graphical representation of real dimensions (lengths, angles, areas). This paper presents some examples of problems solved by means of the simplified rotation method, which leads to more intuitive and simple graphic solutions as compared to the classic rotation method.*

Key words: *Simplified rotation, line, surface, translation, level rotation, front rotation.*

1. INTRODUCTION

In descriptive geometry [1], [2], [3] there is a special chapter which focuses on the geometric item projection transformation methods, from given initial positions into other states, into other more convenient spatial situations, which are more advantageous for solving some metric or position problems. It is speculated that measuring a distance, an angle or calculate the area of a surface can be done on a projection in which the item is in real size (true size). In most cases, the geometric items are arbitrary in relation to the projection planes, so they are deformed. In these situations it is necessary to either change the position of the projection planes that make up the reference system or change the spatial position of the geometrical elements relative to the projection planes.

The descriptive geometry methods for projection transformation are: the rotation method, the folding method and the projection plane changing method.

In the rotation method, the projection planes [H], [V], [W] remain in the unchanged initial positions, only the geometric item in space changes its position by rotation until it occupies a particular position in relation to one of the projection planes. In most common cases, the considered item becomes parallel with or perpendicular to a reference projection plane.

The classic rotation method involves the existence of a rotation axis which is often a line perpendicular to one of the projection planes.

The geometric items are made up of points that rotate in planes perpendicular to the rotation axis, describing circular trajectories [1], [2], [3].

The rotation axis can be a vertical line, perpendicular to [H], in this case the points rotate in level planes, the rotation being called level rotation. If the rotation axis is an end line, perpendicular to [V], the points rotate in front planes and the rotation is called front rotation.

A less-used case is when the rotation axis is a frontal-horizontal line, perpendicular to [W]; the points rotate in a profile plane, thus the rotation here being defined as profile rotation.

Each point involved in the rotation moves on a circle that has the centre at the intersection point between the rotation axis and the plane (most frequently the level or front planes) in which it moves.

The radius of the circular trajectory is equal to the distance between the rotation axis and the rotated point. The rotation of the point is made in a convenient sense and with a chosen angle.

In the case of the simplified rotation method, the rotation axis is eliminated, so it is no longer represented in plane.

There is an axis-free rotation (the rotation axis being only imaginary), which simplifies the drawing of the considered geometric item by making a smaller number of drawings (the rotation circles of all rotated points, the rotation axis and the rotation angle are eliminated).

We apply to the item a level, front or profile rotation associated with a translation (i.e. a rotational-translational movement) or a succession of such imaginary moves in order to reach a particular, convenient position.

The advantage is that, after such a rotational-translational movement, the projection of the geometric item on the corresponding projection plane does not change from the point of view of the shape, the only one modified being the projection position relative to the reference axes OX, OY, OZ.

The new projection must be represented graphically (rotated and translated) and, depending on this, the other projections can be drawn.

If, after a rotational-translational transformation, the projection of the item in real size is not obtained, on a particular projection plane, it is recommended to apply two such transformations successively. If two successive transformations are applied, the rotational movements, logically, are different, that is, each is related to another projection plane. It is recommended to specify the state in which the geometric item is represented. In state I, the object is represented in plane, after the first transformation and, in state II, the object is represented in plane after the second transformation.

Further on in this paper, we shall solve some metric and position problems using the simplified rotation method.

2. FINDING THE REAL SIZE OF THE LENGTH OF A CERTAIN LINE SEGMENT

Figure 1 illustrates the simplified level rotation, with no axis (a vertical line), of a certain AB line segment.

This rotation, combined with a translation, is performed in order to find out the real length of the line segment.

In the initial step (step 0), a certain line segment AB is represented in plane, with the help of the point coordinates A and B. Thus, we may notice the projections ab and a'b'. In the second step (step 1), the item rotates and translates imaginarily until it becomes parallel to the vertical projection plane [V], that is, until a front line segment is obtained. The new state is materialized by means of the projections a_1b_1 and a_1`$b_1$`. In order to obtain it, we have drawn the horizontal projection of the segment -a_1b_1-, in a direction parallel to the OX axis, its length being equal to that of the projection ab, and we have translated it into a convenient place on the [H] plane. Then, we have drawn a_1` and $b_1$` with the same elevations as a` and b`, respectively (here we must note that in a level rotation, the elevations of the points remain constant, invariable). Figure 1 also shows the length of the line segment AB, LAB = 72.801 mm, i.e. the length of the projection a_1`$b_1$`.

The drawings were executed in AutoCAD, the determination of the actual size of the line segment length was performed with the DIST command, thus eliminating the execution and measurement errors.

The drawings used to solve this problem are obviously much simpler than if we had opted to solve this problem by means of another method – the classic rotation method, the folding method or the plane changing method.

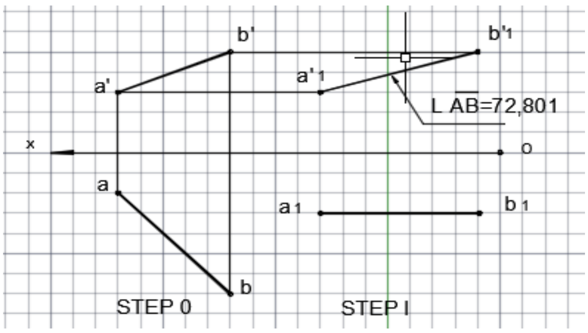

Fig. 1 The simplified level rotation of a certain line segment AB

In Figure 2, we obtained the length of the same line segment AB, considered previously, by using another method, the simplified front rotation method (without a rotation axis, in this case an end line).In the initial step (step 0), a certain line segment AB is represented in plane with the help of the point coordinates A and B. Thus, we may notice the projections ab and a'b'. In the second step (step 1), the element rotates and translates imaginarily until it becomes parallel to the horizontal projection plane [H], that is, until the line segment AB is transformed into a horizontal line segment. The new state is materialized by projections a_1b_1 and a_1`$b_1$`. In order to obtain it, we have drawn the vertical projection of the line segment -a_1'b_1'- in a direction parallel to the OX axis, its length being equal to that of the projection a'b', and we have translated it into a convenient place on the [V] plane. Then, we have drawn a_1 and b_1 at the same distance with the projections a and b, respectively (here we must note that in a front rotation the distance between the points remains invariable). Figure 2 also shows the length of the line segment AB, LAB = 72.801 mm, i.e. the length of the projection a_1b_1.

It can be noticed that, regardless of the method used, the length of the line segment AB has the same value.

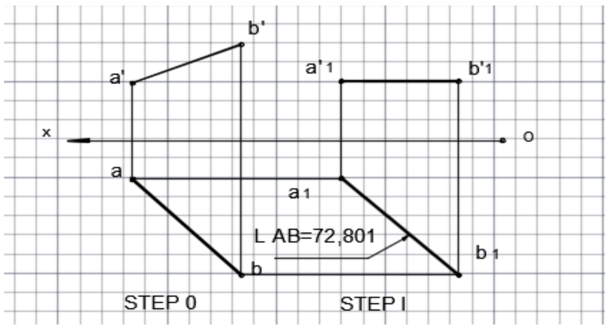

Fig. 2 The simplified front rotation of a certain line segment AB

3. FINDING THE TRUE SIZE OF THE AREA AND PERIMETER OF A PLANE FIGURE

Let's consider the ABCDE plane pentagon, in plane, in two projections, thus generating the initial state, noted with step 0. In order to find out the area and perimeter of this geometric figure located in a certain plane, one has to transform the some plane of the pentagon into a simple particular plane, then into a particular double plane. This transformation is carried out in two steps, marked with step I and step II, respectively, as shown in Fig. 3.

In order to obtain the coordinate plane corresponding to step I, a simplified front rotation was applied to the initial situation. One may notice that the vertical projection [a'b'c'd'e'] rotated around an imaginary end axis until the vertical projection of the front line, the line segment a'f', becomes perpendicular to the OX axis (see a_1'f_1' in Figure 3). Thus, the plane has turned into a vertical plane. In step I, the horizontal projection of the pentagon is materialized by the collinear projections of the vertices, noted $a_1b_1c_1d_1e_1$.

The collinearity of the horizontal projections of the vertices confirms the new vertical plane position of the pentagon. In step II, the plane of the pentagon turns into a front plane by means of a simplified level rotation. The horizontal projection $a_2b_2c_2d_2e_2$ becomes parallel to the OX axis, the front line AF turns into a vertical straight line.

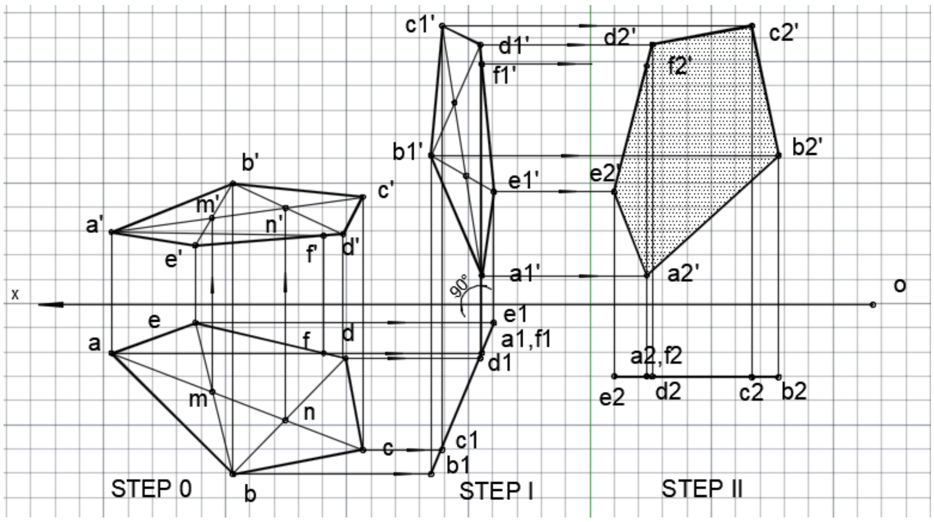

Fig. 3 Finding the area and the perimeter of a certain plane pentagon by means of the simplified rotation method

The vertical projection [a_2'b_2'c_2'd_2'e_2'] is the true size of the pentagon.

With the help of the AutoCAD commands, Area and Perimeter, the area, 4319.4041 mm^2, and the perimeter, 269.7904 mm., are displayed.

4. FINDING THE TRUE SIZE OF THE ANGLE MADE UP OF TWO PLANE GEOMETRIC FIGURES

Let's consider two plane quadrilaterals [ABCD] and [ADEF] that intersect after the AD side. By means of two simplified rotations, carried out in step I and step II, the graphical possibility of measuring the angle between the two different planes is obtained (Fig.4).

The AD side is used to bring the quadrilaterals into the situation from step I. It rotates with 12°, in a clockwise direction to turn it into a frontal line. A simplified level rotation applies to all quadrilateral vertices.

The transition from step I to step II is done by a simplified front rotation. The AD side rotates 68°, in a counter clockwise direction, in order to become a vertical line. In Fig.4 (STEP I) angle between the segment a1'd1' and a horizontal line is 22° (22°+68°=90°).

The planes of the quadrilaterals, in the last stage of work, belong to different vertical planes - [$A_2D_2E_2F_2$] and [$A_2D_2C_2B_2$] -. If you make the representations in AutoCAD, you can also measure the value of the angle between the two plates, which is equal to 166°.

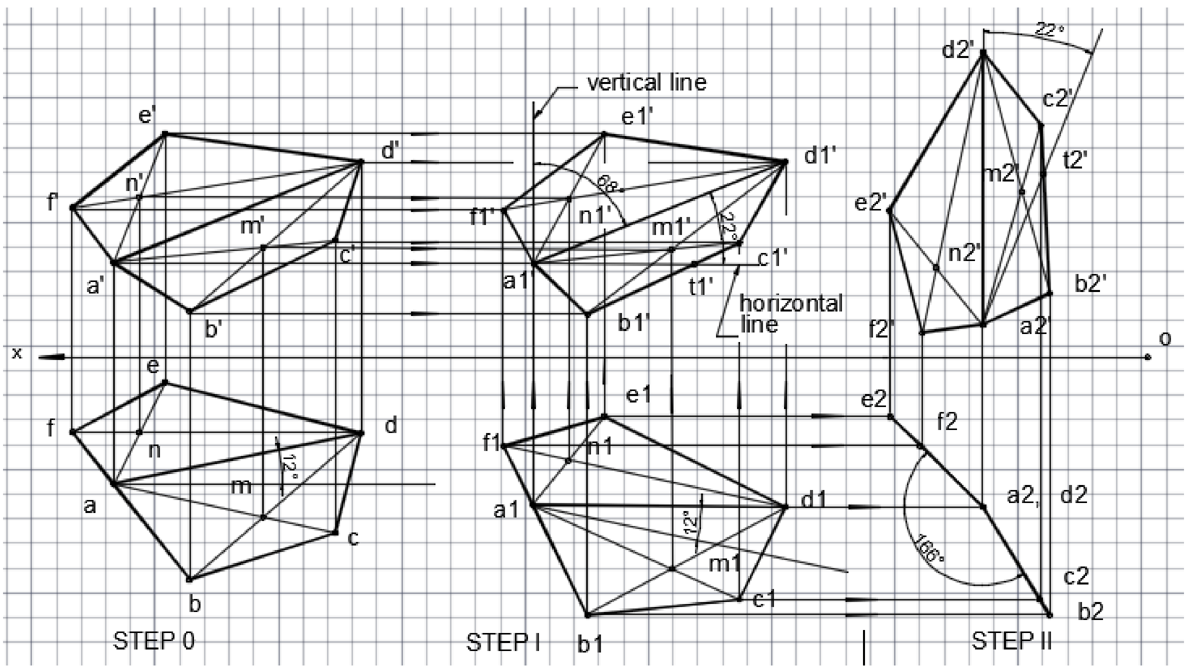

Fig. 4 Finding the angle between two plane geometric figures by means of the simplified rotation method

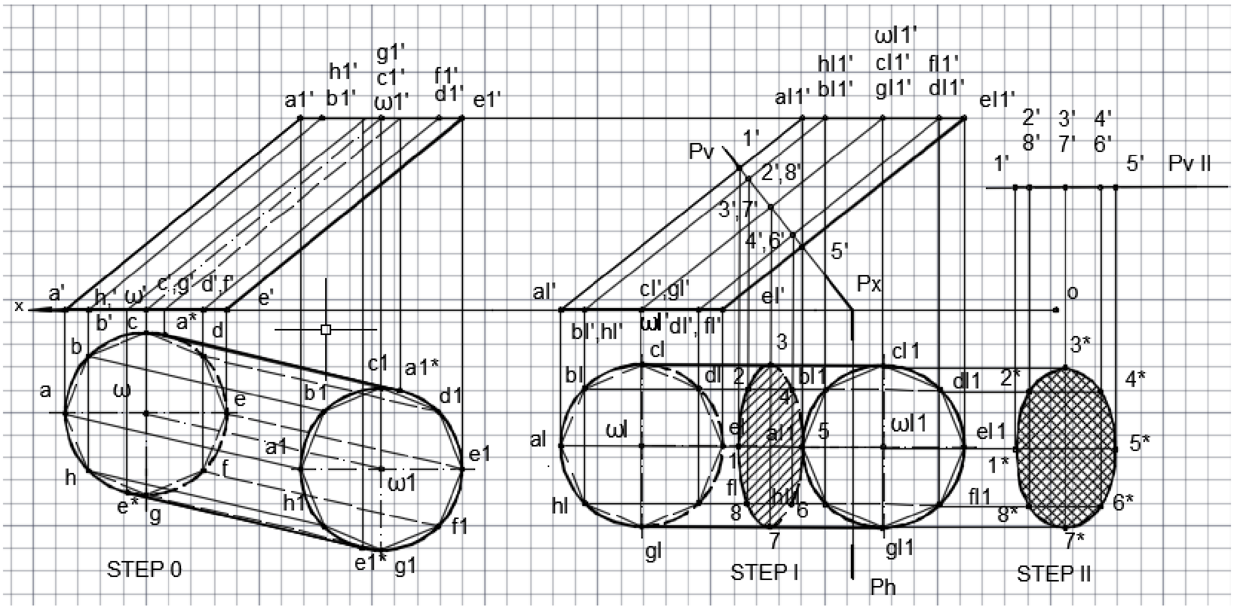

Fig. 5 The determination of the items required to development of an oblique circular cylinder by means of the simplified rotation method

5. THE DETERMINATION OF THE ITEMS REQUIRED TO DEVELOPMENT OF AN OBLIQUE CIRCULAR CYLINDER

In Fig. 5, step 0, we considered an oblique circular cylinder with the lower base circle in plane [H] and the centre in point Ω, the centre of the upper base being in Ω_1. The axis of the cylinder, $\Omega\Omega_1$, is a certain line segment.

In this case, the elements necessary for the development are: the true size of the generating lines, the true size of the straight section and the distance of this section from one of the bases, the basic circles according to [1], [2], [3].

One may notice that, by means of the simplified rotation method (the level simplified rotation in step I and the front simplified rotation in step II), we determined the geometrical elements necessary for the development. The generating lines became frontal lines in step I and, in step II, the plane of the straight section turned into a level plane.

Compared to classic methods, the simplified rotation method has the advantage of being more intuitive, faster, involving a small number of graphical operations, requiring less space for representation, and it is more accurate due to the use of the AutoCAD commands.

Similarly, the method may apply to any oblique prism.

6. CONCLUSION

The paper presents the advantages of using the simplified rotation method in solving some descriptive geometry problems. The previously presented examples of fast and efficient solutions found to the descriptive geometry applications, which are important for the technical field, are original, illustrating the contribution of the author and representing the original part of this paper. Using the modern design and representation tool, the AutoCAD software, in descriptive geometry, is a novelty element in the teaching process that should be implemented in the current study curricula. This is justified because a large number of students study computerized representation methods in high school.

The use of computerized representations is a modern means of teaching, drawing, determining useful information in design, such as: distances, angles, areas, perimeters. The computerized graphics software provides facilities in applying the method to imaginary rotation, translation, copying, and moving operations that presuppose accuracy and speed of execution.

Another aspect to be considered is the computer know-how the young generation of students has.

As far as the disciplines presented in the curricula, it is compulsory to combine harmoniously the fundamental study subjects with the modern study subjects that develop the skills of representation, which are extremely useful to an engineer.

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