Buletinul Ştiinţific al Universităţii "POLITEHNICA" din Timişoara

Seria HIDROTEHNICA
TRANSACTIONS on HYDROTECHNICS

Tom 58(72), Fascicola 2, 2013

The Intersection of Polyhedrons – Teaching - Learning Aspects

Madalina RUS[1] Silvia VEREȘIU[1] Elena MEREUȚĂ[1]

Abstract: The extension of the usage of CAD programmes could create the impression that the traditional graphical representations are old-fashioned. In reality, graphical abilities are a main part of the students teaching in engeering.
This paper shows the importance of understanding the real model through graphical representation using notions learned during the Descriptive Geometry discipline.
Keywords: polyhedrons, intersection, visibility, auxiliary plane.

1. INTRODUCTION

Due to the appearance of CAD programmes in designing, students tend to consider that drawing on paper, using drawing tools and what they have learned during Descriptive Geometry discipline, is old-fashioned.

In reality, the drawing commands used in CAD programmes need clear, fundamental notions from technical drawing.

Next, the paper will show a Descriptive Geometry application worked with students during lab.

2. THE INTERSECTION OF POLYHEDRONS. GENERALITIES

The intersection of solids supposes to determine the common points of surfaces.

This thing, is possible by using the auxiliary planes chosen so as to intersect surfaces by lines that can be built directly.

Stages to be completed for solving geometric intersection are:

1. Determining auxiliary planes that sections longitudinal solids;
2. Establishing the type of intersection: breaking, total crossing, simple crossing tangential, double crossing tangential;
3. Determine the current points of intersection;
4. The determination of the joining order of the crossing polygon (s) points;
5. The clarification visibility.

Considering two polyhedrons, they can intersect themselves in one or two polygons according to their relative position.

If the polyhedrons intersect in one polygon then the crossing point is partial and it is called breaking.

In this case the resulting polygon is always crooked.

If the polyhedrons intersect in two polygons, then the crossing point is total and it is called total crossing. The resulting polygons can be: plane, crooked or one plane and one croked.

If the crossing polygon have a joint point, the intersection is simple crossing tangential.

If the crossing polygons have two joint points, the intersection is double crossing tangential.

It is necessary to use one of the two classical methods i.e. the mobile method and the schematic evolutes method, for the succession of the points of the crossing polygon and as well for its visibility [3].

a) The method of the mobile

Supposses to consider a mobile *M* which moves in space on the sides of the crossing polygon. The projections of the mobile *M* are considered to start from the same limit plane surface and in the same direction, following the outline of the two bases.

In order to make the sides of the crossing polygon visible, the way covered by the mobile on the outline of the bases is followed [2].

b) The method of the schematic evolutes

Allows both the determination of the joining order of the crossing polygon (s) point and the study of visibility. For this method, the evolutes of the two polyhedrons are schematically represented, underlining the points in which the edges of the polyhedron intersect the surfaces of the other and vice-versa.

The following aspects are taken into consideration for the representation:

1. Only the edges of the lateral surfaces are represented without taking into consideration their sizes and the distances between them;
2. The two evolutes are built overlapping,

[1] "Dunarea de Jos" University of Galati, Faculty of Mechanical Engineering, Applied Mechanics Department, str. Domneasca Nr.111, Galati, Romania, madalina.rus@ugal.ro; silvia.veresiu@ugal.ro; elena.mereuta@ugal.ro

considering that the edges of the polyhedron are perpendicular in point of direction on the edges of the other polyhedron;

3. The edges that do not take part in the crossing are drawn at the extremity;

4. The points from the same surface are always joined; in this way the joining order of the transposed points on the two schematic evolutes results;

5. The visible sides of the crossing polygon are obtained due the crossing between the visible surfaces for each plane surface taken separately.

The visible sides are drawn using a continuous line, and the invisible sides one using a broken line [1].

In order to exemplify it considers the intersection of two triangular prisms which have the bases in the same projection plane surface.

3. CASE OF STUDY. THE INTERSECTION OF TWO TRIANGULAR PRISMS

There are considered two prisms having the bases ABC and MNP in the plane surface [H] (Figure 1).

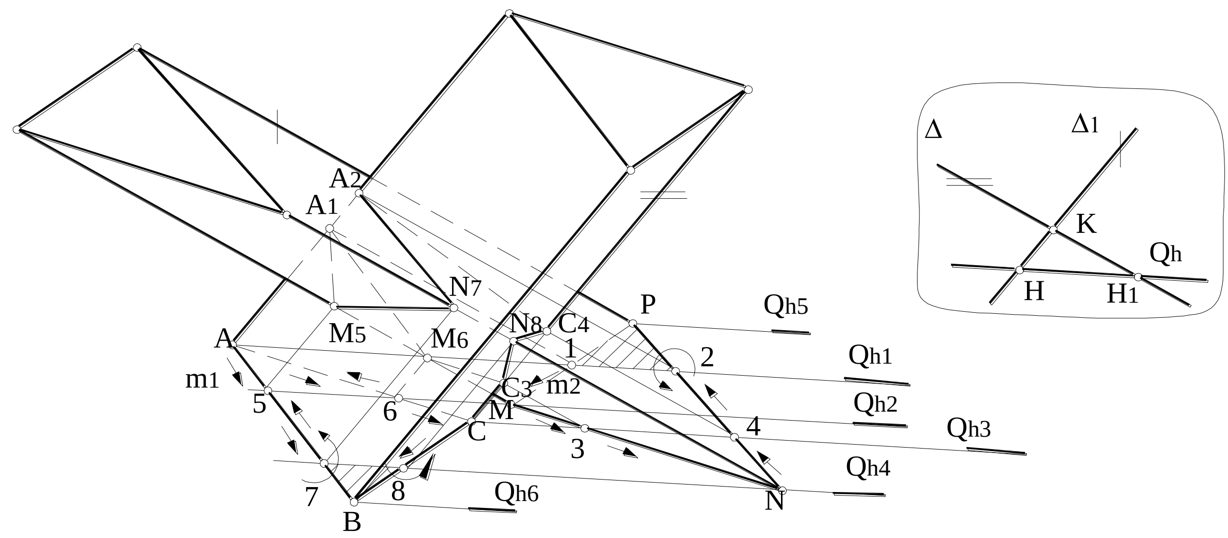

Fig.1 – The intersection of two triangular prisms in space

In order to solve the intersection of two prisms it is necessary to built section auxiliary plane surfaces Q_i through the edges that take part in the crossing.

The direction of these plane surfaces is established by building through an external point *K* the straight lines Δ and Δ_1, parallel to the directions of the edges of the two prisms. The horizontal trace of the plane surface made by the two straight lines Q_h are determined and then the traces of the plane surfaces Q_{hi} ll Q_h are drawn through the points of the two bases.

It can be observed that the points P and B do not take part into the crossing because the traces Q_{h5} and Q_{h6} drawn through these points do not intersect the baese ABC or MNP.

The traces Q_{h1} drawn through A meets the base MNP in the points 1 and 2 (1 є MP and 2 є PN) from where the generatrices that meet lateral edge of A in the points A_1 and A_2 are built.

The traces Q_{h2} drawn through M meets the base ABC in the points 5 and 6 (5 є AB and 6 є AC) from where the generatrices that meet lateral edge of M in the points M_5 and M_6 are built.

The traces Q_{h3} drawn through C meets the base MNP in the points 3 and 4 (3 є MN and 4 є PN) from where the generatrices that meet lateral edge of C in the points C_3 and C_4 are built.

The traces Q_{h4} drawn through N meets the base ABC in the points 7 and 8 (7 є AB and 8 є BC) from where the generatrices that meet lateral edge of N in the points N_7 and N_8 are built.

The purge intersection polygon construction desribed above is illustrated in figure 2.

The methods mentioned above are used for the joining order of the points and for the visibility of the crossing [2].

3.1. THE METHOD OF THE MOBILE *M*

The mobiles m_1 and m_2 that start from the same limit plane surface and go in the same direction are considered.

For the considered case the limit starting plane surface for both mobiles is Q_{h1}.

The mobile m_1 starts from point *a* and m_2 starts from point *1* resulting the point a_1.

The mobile m_1 reaches point *5* and the mobile m_2 reaches point *m* resulting the point m_5.

The mobile m_1 reaches point *7* and the mobile m_2 reaches point *n* resulting the point n_7.

The mobile m_1 reaches the shading zone (that does not take part in the intersection) and enters inside it returning to the point *a* while the mobile m_2 reaches the point *2* resulting the point a_2.

When m_2 reaches point *2* (the shading zone), it also must enter inside it reaches point *4* and mobile m_1 reaches point *c* resulting the point c_4.

The mobile m_1 reaches point *8* and the mobile m_2 reaches point *n* resulting the point n_8.

After reaching point *8*, mobile m_1 must get out of the zone (the shading zone) and reaches point *c* and the mobile m_2 reaches point *3* resulting the point c_3.

The mobile m_1 reaches point *6* and the mobile m_2 reaches point *m* resulting the point m_6.

The mobile m_1 reaches point *a* and the mobile m_2 reaches point *1* resulting the point a_1.

In order to have visibility in the plane surfaces [H] and [V] the way covered on the bases outline by each mobile is followed.

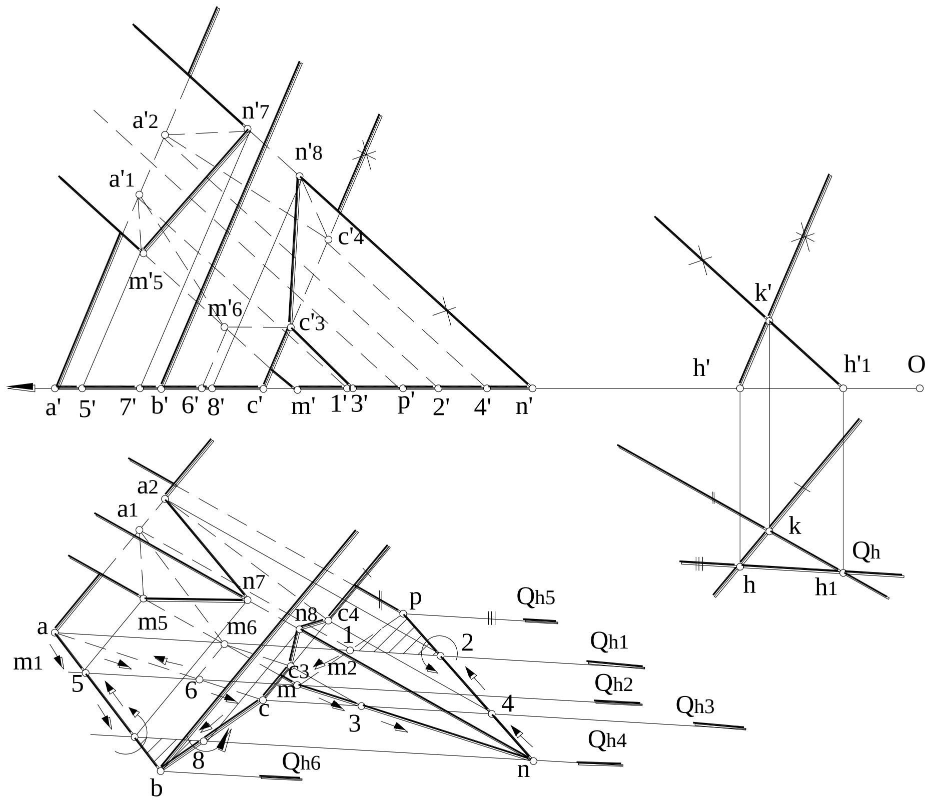

Fig.2. – Intersection of the two triangular prisms in plane surface [H] and [V]

The joining order of the points and the visibility of the sides is exemplified in the table below.

The visible sides are drawn using a continuous line, and the invisible sides one using a broken line.

<table>
<tr><td colspan="3">m Є [ABC]</td><td>a</td><td>5</td><td>7</td><td>a</td><td>c</td><td>8</td><td>c</td><td>6</td><td>a</td></tr>
<tr><td colspan="3">m1 Є [MNP]</td><td>1</td><td>m</td><td>n</td><td>2</td><td>4</td><td>n</td><td>3</td><td>m</td><td>1</td></tr>
<tr><td colspan="3">M Є ∩</td><td>A1</td><td>M5</td><td>N7</td><td>A2</td><td>C4</td><td>N8</td><td>C3</td><td>M6</td><td>A1</td></tr>
<tr><td rowspan="6">Vizibilitate</td><td rowspan="3">[H]</td><td>[ABC]</td><td colspan="9">———————— ------ —————— ---------------</td></tr>
<tr><td>[MNP]</td><td colspan="9">--------- ———————————————————— ---------</td></tr>
<tr><td>∩</td><td colspan="9">--------- ———————— ------ —————— ---------------</td></tr>
<tr><td rowspan="3">[V]</td><td>[ABC]</td><td colspan="9">———————— ------ —————— ---------------</td></tr>
<tr><td>[MNP]</td><td colspan="9">--------- ——— ------------------ ——————— --------</td></tr>
<tr><td>∩</td><td colspan="9">--------- ——— ------------------ ——— ---------------</td></tr>
</table>

Table 1. – Visibility of the crossing polygon

3.2. THE METHOD OF THE SCHEMATIC EVOLUTES

Only the lateral edges that are perpendicular as direction and the crossing points as in figure 3 are represented.

The visible and invisible surfaces on the plane surfaces [H] and [V] are written using *v* and *i*.

The visible sides of the crossing polygon are obtained from the crossing between the visible surfaces: M_5N_7, N_7A_2, C_4N_8 and N_8C_3 (in the plane surface [H]) and M_5N_7 and N_8C_3 in the plane surface [V] [1].

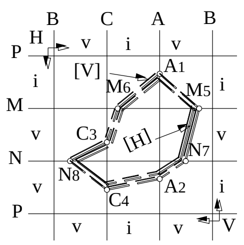

Fig.3. - The visible sides of the crossing polygon

4. CONCLUSIONS

1. It can be seen that no matter the method we choose to determine the joining order of the points of the crossing polygon as well as of its visibility, the result is the same.

2. The method of the schematic evolutes is more simple and faster in determinig the visibility of the crossing polygon.

3. The method of the mobile M is more laborious and needs more attention in creating the table but it is more clear for each projection plane surface taken separately.

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