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Some Issues on the Intersection of Curved Surfaces Applied in Technical Drawing

Thu Huong Nguyen

Hanoi University of Science and Technology, 1 Dai Co Viet Ha Noi, Viet Nam

Abstract **- Drawing the intersection of two curved faces is an important issue in technical drawing. There are two types of problem: a special case when one of the two curved surfaces is a cylinder and a general case with any two curved surfaces. In principle, it is necessary to find the projections of some necessary points, then connect the intersection line according to the defined form. The connection of the line in any order is a difficult problem. The article presents the rule of how to connect the line of the problem of a cylinder intersecting with a number of curved surfaces. In addition, the article also shows how to apply the theoretical problem of assigning two curved surfaces and the observed - hidden rule in the practice of drawing a single-cross shape.**

Keywords: line connection, observed - hidden, single-cross shape.

I. Introduction

The intersection of curved surfaces is an extremely important issue; it is the basis for drawing representations of objects. In descriptive geometry books, they only provide methods for determining the points of the intersection line and a few considerations when drawing the projections of the intersection line without presenting the rules for connecting the intersection line. Therefore, when connecting the intersection line, intuition and experience are often used, making the connection difficult and prone to mistakes. This article is based on logical reasoning and theorems on intersection lines to formulate a rule for connecting intersection lines. The research scope of this rule is limited to applying only to the intersection cases of a projecting cylindrical surface with a conical surface, a spherical surface, and another projecting cylindrical surface. Another issue we want to mention is applying the theoretical problem of intersection of two curved surfaces into the practice of drawing a single-cross shape. Currently, there is no document mentioning this issue. The article relies on logical reasoning and Boolean operations to provide rules relating the theory of intersection of two curved surfaces and the problem of drawing single-cross shapes.

II. Rules for connecting intersection lines

Statement of the rule: The problem posed is to draw the intersection line of two curved surfaces, in which at least one curved surface is a frontal-projecting or horizontal-projecting cylinder. We call the projecting cylindrical surface the first curved surface, and the other is the second curved surface. A generatrix of the first curved surface may not intersect the second curved surface, or be tangent to the second curved surface, or intersect the second curved surface at 2 points. If 1 generatrix of the first curved surface intersects the second curved surface at 2 points, we add a prime mark "'" to the name of the second intersection point. For example, if the first intersection point is A, the second intersection point is A' and must be named according to the same rule of order (top - bottom, left - right). The rule for connecting the projection of the intersection line is stated as follows: based on the known projection of the intersection line, connect them sequentially, without skipping any point, in any chosen direction. When the intersection line meets a contour of the second curved surface, if it can still proceed in the chosen direction, continue connecting; if it cannot proceed in the chosen direction because there are no more points, turn back. In both cases of proceeding or turning back, the sign of the point must be changed. When turning back, if encountering a point located on the contour of the second curved surface, the intersection line must still be connected to that point. When the intersection line is closed but there are still unconnected points, a second connection cycle must be initiated, starting from any unconnected point and still following the above rule, Illustrative examples. In Figure 1, the frontal projection of the intersection line between the cylinder and the sphere is a circular arc segment with a radius equal to the cylinder's radius, going from 11 to 61 in a counterclockwise direction. According to the above principle, the intersection line connected sequentially will be 1→2→3→4→5→6. At this point, meeting point 6 located on the frontal projection contour of the sphere, there are no more points to connect in the counterclockwise direction, so we turn back but will change the sign (connect to points with prime marks): 6→5'→4'→3'→2'→1. The intersection line is already closed and there are no unconnected points left, so the connection process is complete. Note that when saying: sequentially connecting 1→2→3→4→5→6→5'→4'→3'→2'→1 is

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connecting in space, it should be understood that on the frontal projection, we will sequentially connect 11→21→31→41→51→61→5'1→4'1→3'1→2'1→11, and on the horizontal projection we will sequentially connect 12→22→32→42→52→62→5'2→4'2→3'2→2'2→12.

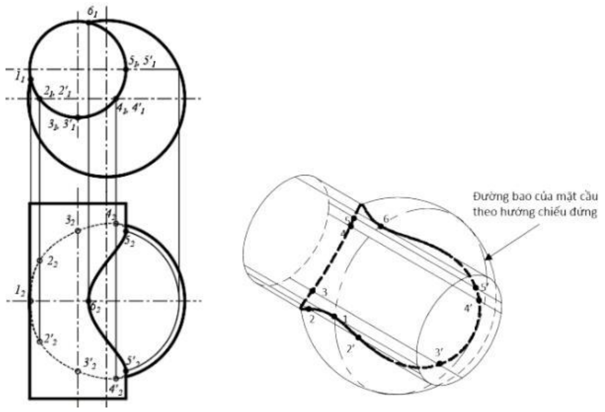

Figure 1: Illustration 1 of intersection line connection

In Figure 2, the frontal projection of the intersection line between the cylinder and the cone is a circular arc segment with a radius equal to the cylinder's radius, going from 11 to 51 in a counterclockwise direction. According to the above principle, the intersection line connected sequentially will be 1→2→3→4. At this point, meeting point 4 located on the frontal projection contour of the cone, there are still points to connect in the counterclockwise direction, so we proceed but will change the sign (connect to points with prime marks): 4→5'→6. At this point, in the counterclockwise direction there are no more points to connect, so we turn back but will change the sign: 6→5'→4. According to the above principle, here we will proceed, but change the sign: 4→3→2→1. The intersection line is closed and there are no unconnected points left, so the connection process is complete.

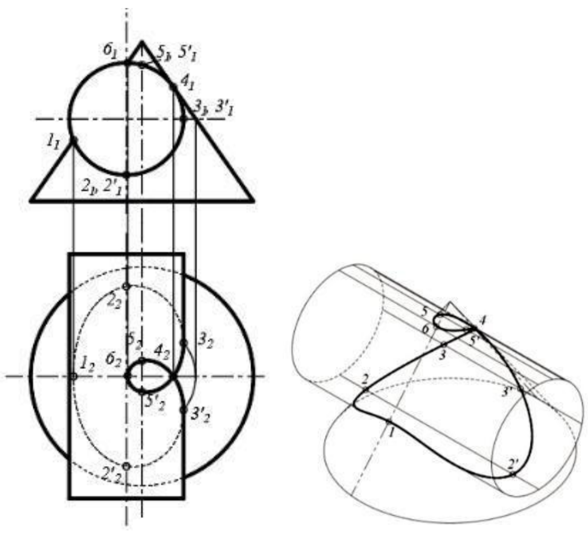

Figure 2: Illustration 2 of intersection line connection principle

Figure 3 describes the application of the intersection line connection principle presented above. The connection order is as follows: 1→2→3→4→5→6'→1. At this point, the intersection line is already closed but there are still unconnected points, so a new connection cycle must be initiated, still following the above principle: 2'→3'→4'→5→6→1→2'. The intersection line connection is complete.

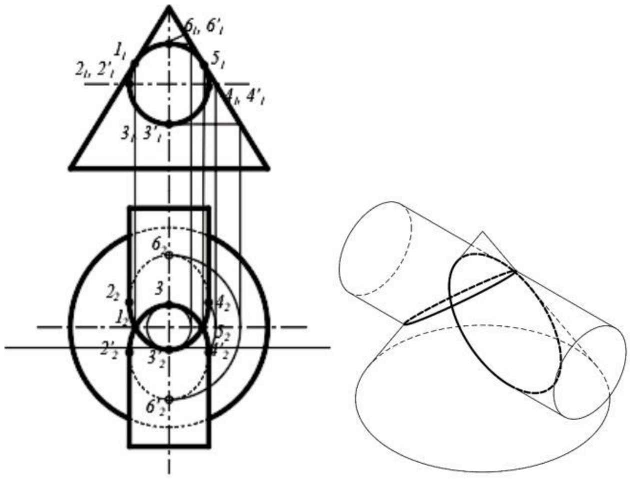

Figure 3: Illustration 3 of intersection line connection principle

III. Applying the drawing of the intersection of two curved surfaces into the practice of single-cross shape problems

General principles: The main contents when drawing single-cross shapes are: intersection of surfaces; drawing contours, edges; determining the observed - hidden status of contours and edges. The article addresses the following issues: drawing procedure; determining the observed - hidden status of intersection lines; drawing projection contours of curved surfaces. The research scope is limited to a cylinder, cone, or sphere intersecting with a projecting cylindrical surface. The proposed procedure for solving the single-cross shape problem is as follows: solve the intersection problem of two curved surfaces, determine the observed - hidden status of the intersection of two curved surfaces → Determine the single-cross shape problem: subtractive cross (creating a hole), additive cross, or taking the intersection part → Re-examine the observed - hidden status of the intersection line if it is a subtractive cross problem → Consider adding or removing the projection contour of the curved surface

Determining the observed - hidden status of the intersection of 2 curved surfaces is performed according to the principle: a point on the intersection line is an observed point only if it is an observed point considered on both curved surfaces. Re-examining the observed - hidden status when applied to drawing cross shapes in the case of a subtractive cross follows this principle: first, on the projection being

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considered, remove the projection contour segments of the curved surface that have been cut away. If after removing the projection contour segments of the curved surface, a hidden intersection line segment of the 2 curved surfaces becomes the outermost line of the projection, it is changed to observed. The addition or removal of a projection contour segment of a curved surface depends on whether the cross shape problem is additive, subtractive, or taking the common intersection. In case of a subtractive cross: add the projection contours of the curved surface acting as a hole, remove the projection contour part of the curved surface corresponding to the hole that lies outside the other curved surface. In case of an additive cross: add the projection contour parts of the curved surfaces that lie outside the other curved surface; remove the projection contour part of one curved surface that lies inside the other curved surface. In case of taking the intersection of two volumes: add the projection contour parts of one curved surface that lie inside the other curved surface; remove the projection contour part of one curved surface that lies outside the other curved surface.

Illustrative examples: Figure 4 describes a problem of drawing the intersection line between a cylinder and a sphere. Figure 5 illustrates the result of the single-cross shape problem in the case of an additive cross. Compared with Figure 4, on the frontal projection we have removed the projection contour part of the sphere located inside the cylinder; on the horizontal projection, we have removed the projection contour part of the cylinder located inside the sphere and the projection contour part of the sphere located inside the cylinder.

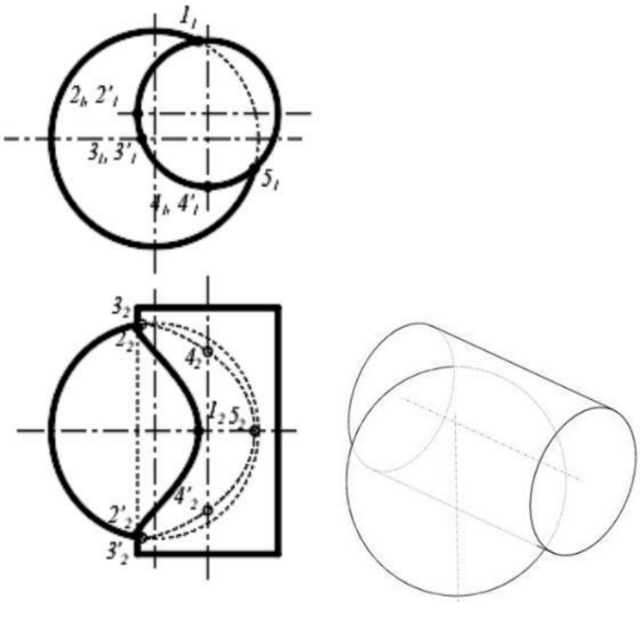

Figure 4: Drawing the intersection line of two curved surfaces

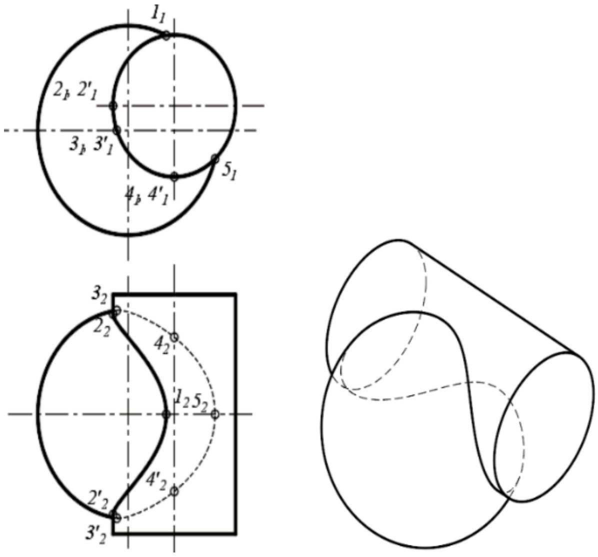

Figure 5: Additive cross shape problem

Figure 6 illustrates the result of the subtractive single-cross problem. On the projection, we have removed a part of the sphere's projection contour and the cylinder's projection contour, and as a result, the intersection line segment 2242524’23’22’2 becomes the outermost line of the horizontal projection; according to the above principle, it is changed to an observed stroke. The horizontal projection contour segment of the cylinder, the part located inside the sphere 222’2, is retained in the role of the contour of the cylindrical hole.

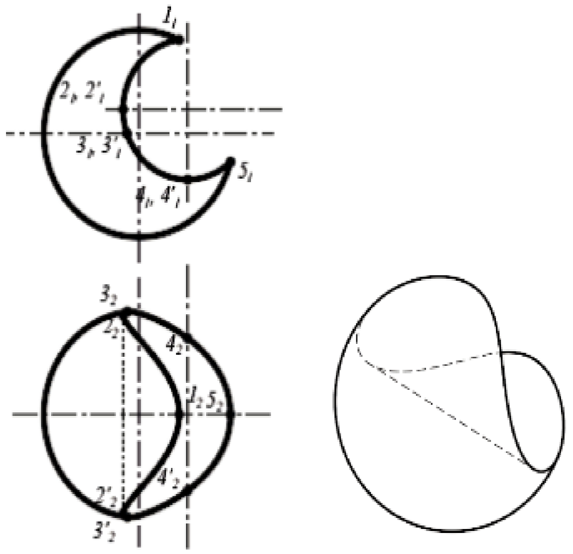

Figure 6: Subtractive cross shape problem

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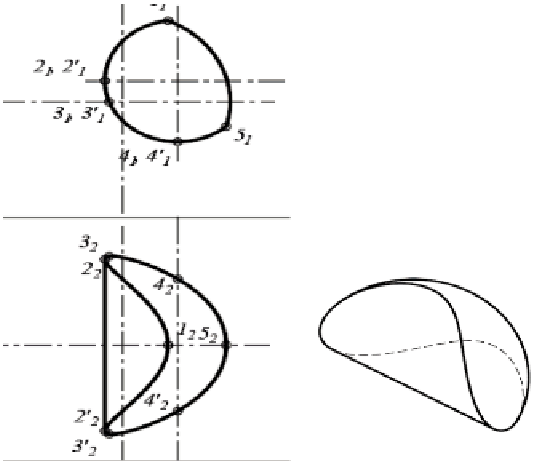

Figure 7: Intersectional cross shape problem

Figure 7 is the result of the cross shape problem of taking the common intersection part of the two spherical and cylindrical volumes applying the principles presented above.

IV. Conclusion

This article has solved the following issues: providing a rule for connecting the projections of intersection lines, and simultaneously proposing a procedure to apply the problem of intersection of two curved surfaces into the practice of drawing cross shapes. The article limits its research to the class of problems involving simple curved surfaces, which are common and therefore widely applied in reality.

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