METHODS FOR DETERMINING THE CONFIGURATION OF THE CONNECTIONS OF SOME CONTAINERS USED IN THE INDUSTRIAL EQUIPMENTS

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Abstract. The connections located on the surface of some containers serving various industrial equipments, have similar configurations of a cylindrical, conical shapes, etc. The design, the execution and their installation requires the knowledge of their unfolding, to assembly the cut iron plate, after the transformed contour of the container sections. The connections are found in all the industrial equipments and consist of intersections thin-walled vessels. The design, the execution and their installation requires tracing of the unfolding of the geometric elements of the respective connection.

The paper proposes to establish the unfolding of a connection used in the industrial equipments, by the classical method of the descriptive geometry and mathematics, using appropriate software. Which method is more accurate or faster is up to the user. The descriptive geometry method has the advantage that once drew the connection is relatively easy to determine its unfolding, measuring geometrical elements, mentioned in the paper. The disadvantage is that the connection has to be drawn, for each size of diameters, plus the required accuracy of the drawing program.

Keywords: cylinder, intersection curve, unfolding, particular plane, methods

1. Theoretical considerations

The connections are found in all the industrial equipments and consist of intersections thin-walled vessels. The design, the execution and their installation requires tracing of the unfolding of the geometric elements of the respective connection. This paper aims to resolve in two ways, by methods of the descriptive geometry and mathematics, such an application.

2. The descriptive geometry method

The connections as those shown in the figure 1 are common in the industrial equipments. The problem is reduced to two types of intersections:
- the intersection of two cylinders with equal diameters and inclined competing axes;
- the intersection of two cylinders of different diameters and inclined competing axes [1, 2, 3].

To determine the curve of intersection between the cylinders we use the method of the auxiliary planes. The number of auxiliary planes is greater; obvious the accuracy of the intersection curve is higher (figure 2).

2.1. The case of two cylinders with equal diameters and inclined competing axes

To determine the curve of intersection, the base of the inclined cylinder is divided in equally planes a'_1, b'_1, …, g'_1 where the planes $P_{v1},...,P_{v4}$ .des are traced. At their intersection, the points belonging to the curve of intersection are found 1', 2', …, 7'.

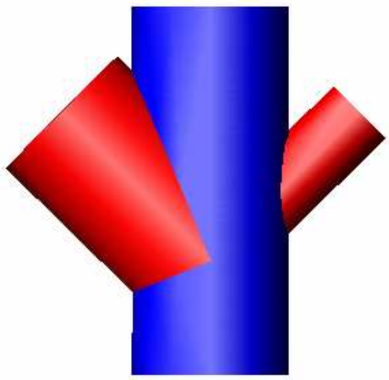

Figure 1. The shape of a connection

The intersection is tangential type, and the curve of intersection is represented in the apparent plan $[V]$ by two straight lines, competition at the point of intersection of the axis of the cylinders $\overline{1'4'},\overline{4'7'}$. To establish the unfolding of the inclined cylinder a_o, …, g_o, 1_o, …, 7_o (figure 3) it was built the unfolded length of the base circle a_o, …, g_o, where we trace the lengths of the generator 1_o, 2_o, …, 7_o, measured in the vertical plane $\overline{a'1'},\overline{b'2'},...,\overline{g'7'}$ (figure 3).

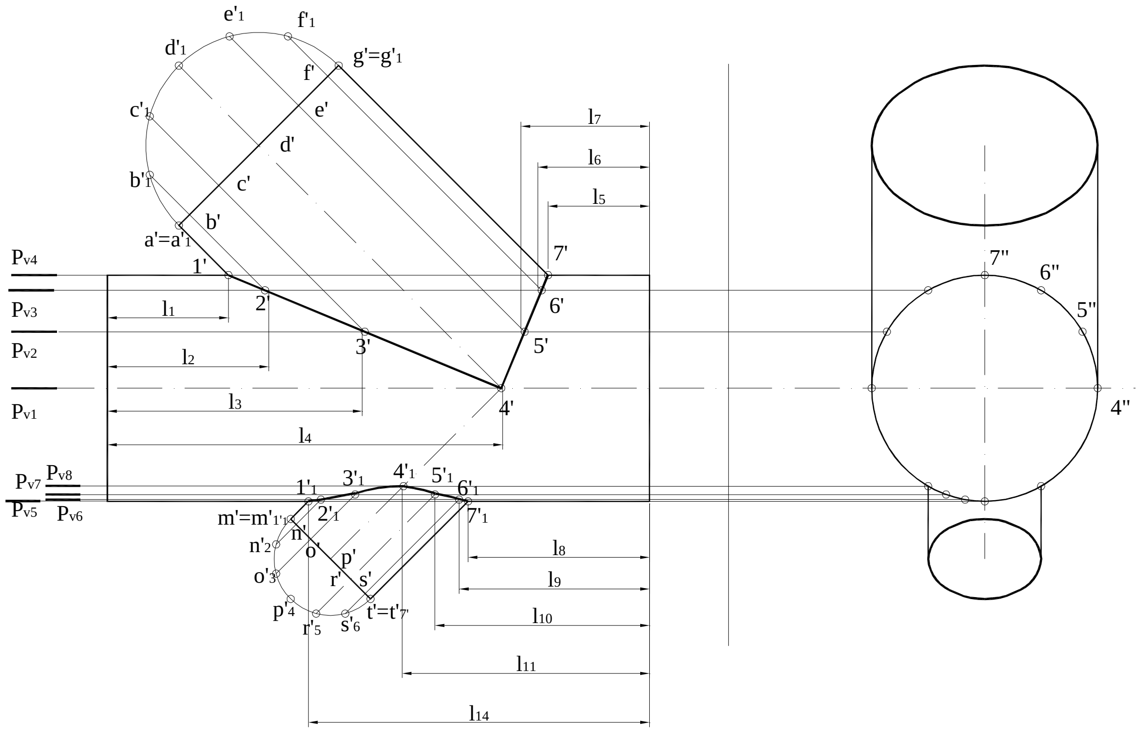

Figure 2. Determination of the curve of intersection between the cylinders

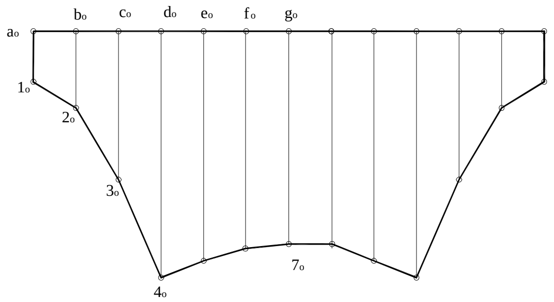

Figure 3. The unfolding of the inclined cylinder of the same diameter

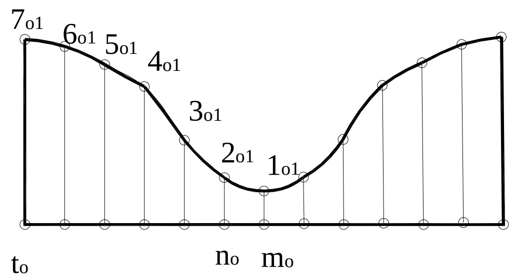

Figure 4. The unfolding of the inclined cylinder of smaller diameter

2.2. The case of two cylinders with different diameters and inclined competing axes

Similarly, the planes will be P_{v5}, …, P_{v8}, the points where the base of the inclined cylinder is divided are m'_1, n'_2, …, t'_7, and the points of intersection curve are $1'_1$, $2'_1$, $7'_1$. To establish the unfolding (figure 4), the length of the base circle is drawn t_o, …, m_o and was measured the length of the generators from the vertical plane $\overline{m'1'_1}, \overline{n'2'_1}, ..., \overline{t'7'_1}$.

2.3. The unfolding of the horizontal cylinder

The unfolding of the horizontal cylinder is a rectangle, with one side equal with the unfolded length of the base circle and the other side equal with the generators lengths l_1, l_2, …, l_7, for the intersection with the cylinder of the same size and l_8, l_9, …, l_{14} (figure 5).

3. The mathematical method of establishing the intersections curves

The projection of the intersection curves necessitates the solving of the following phases [4, 5]:
- the writing of the curves equations resulted from the intersections of the areas that can be unfolded;
- the writing of the transformations equations by the unfolding of the intersection curve.

3.1. The calculation of the intersection curves γ_1 and γ_2 of the cylinder C and C_1, and the intersection curves γ_3 and γ_4 of the cylinder C and C_2

In accordance with figure 6 we take the cylinder C, of diameter D = 60 mm, and its reference system Oxyz and the cylinder C_1, of diameter D_1 = 30 mm, and its reference system $O_1x_1y_1z_1$, where $y \equiv y_1$ and $O \equiv O_1$. The third cylinder C_2 has the diameter D_3 = 60 mm. It is also known the angle $\varphi = 45^0$.

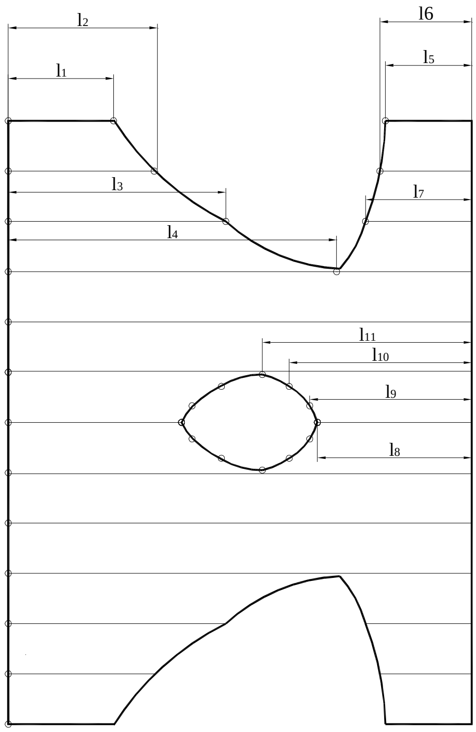

Figure 5. The unfolding of the horizontal cylinder

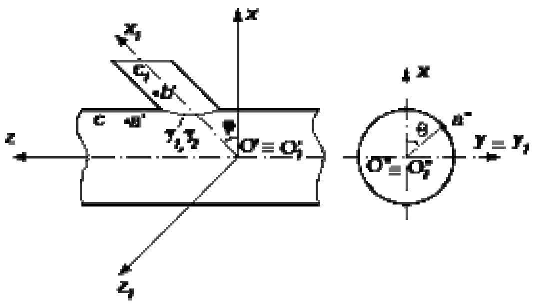

Figure 6. The geometrical elements of the cylinders

The cylinders equations expressed in the chosen reference systems are [6]:

$$x^2 + y^2 = R^2\,, \tag{1}$$

$$y^2 + z_1^2 = R_1^2\,. \tag{2}$$

The two reference system are rotated, one given another, by the φ angle.

The transformation formula of the coordinates, to passing from the system Oxyz into $O_1x_1y_1z_1$ and vice versa are:

$$x_1 = x \cdot \cos\varphi + z \cdot \sin\varphi\,, \tag{3}$$

$$z_1 = z \cdot \cos\varphi - x \cdot \sin\varphi\,, \tag{4}$$

$$x = x_1 \cdot \cos\varphi - z_1 \cdot \sin\varphi\,, \tag{5}$$

$$z = x_1 \cdot \sin\varphi + z_1 \cdot \cos\varphi\,. \tag{6}$$

Relating the equations of the both cylinders to system Oxyz and by eliminating the variable *y*, we obtain the equation of the vertical projection of the intersection:

$$z^2 - 2x \cdot z \cdot tg\varphi + \frac{R^2 - R_1^2}{\cos^2\varphi} - x^2 = 0\,. \tag{7}$$

The equation of the transformation curve γ_1, border of the cylinder C, is obtained by applying the transformations (8, 9) to the equation (7).

$$x = R \cdot \cos\theta = R\cos\frac{x_d}{R}\,, \tag{8}$$

$$z = z_d\,, \tag{9}$$

where x_d and z_d are the coordinates of the point A in unfolding. This point A is indicated by its projections a' and a".

In this case the following equation is obtained:

$$\begin{aligned} &z_d^2 - 2R \cdot z_d \cdot \cos\frac{x_d}{R} \cdot tg\varphi + \\ &+ \frac{R^2 - R_1^2}{\cos^2\varphi} - R^2 \cdot \cos^2\frac{x_d}{R} = 0\,. \end{aligned} \tag{10}$$

Then:

$$\begin{aligned} z_{d1,2} &= R \cdot \cos\frac{x_d}{R} \cdot tg\varphi \pm \\ &\frac{1}{\cos\varphi} \cdot \sqrt{R_1^2 - R^2 \cdot \sin^2\frac{x_d}{R}}\,, \end{aligned} \tag{11}$$

$$x_d \in \left[-R \cdot \arcsin\frac{R_1}{R},\quad R \cdot \arcsin\frac{R_1}{R}\right].$$

Figure 7 and 8 were obtained the by introducing the relations (11) into Mathematica program.

The equation of the transformation curve γ_2, border of the cylinder C_1, is obtained by applying the transformations (12, 13) to the equation (7):

$$x_1 = x_{d1}\,, \tag{12}$$

$$z_1 = R_1 \cdot \sin\alpha = R_1 \cdot \sin\frac{z_{d1}}{R}\,, \tag{13}$$

where x_{d1} and z_{d1} are the coordinates of the point B(b', b) in unfolding.

The following equation is obtained:

$$\begin{aligned} &x_{d1}^2 + 2R_1 \cdot x_{d1} \cdot \sin\frac{z_{d1}}{R_1} - \\ &- R_1^2 \cdot \sin^2\frac{z_{d1}}{R_1} - \frac{R^2 - R_1^2}{\cos^2\varphi} = 0\,. \end{aligned} \tag{14}$$

Then:

$$x_{d1} = -R_1 \cdot \sin\frac{z_{d1}}{R_1} \pm \frac{1}{\cos\varphi} \cdot \sqrt{R^2 - R_1^2 \cdot \cos^2\frac{z_{d1}}{R_1}}\,, \tag{14}$$

$$z_{d1} \in [0,\ 2\pi R].$$

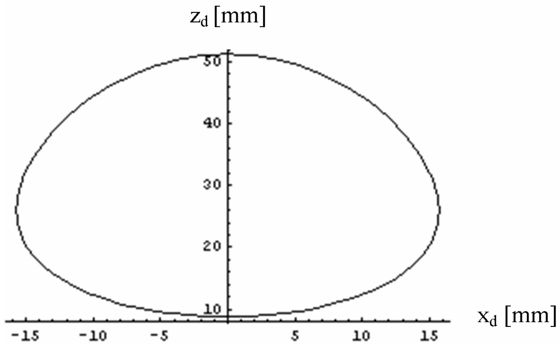

Figure7. The unfolding of the intersection curve γ_1 of the cylinder C

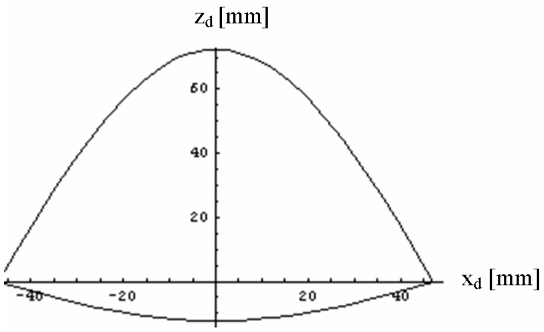

Figure 8. The unfolding of the intersection curve γ_3 of the cylinder C

The figure 9 and 10 are obtained by introducing the relations (15, 16) into Mathematica program.

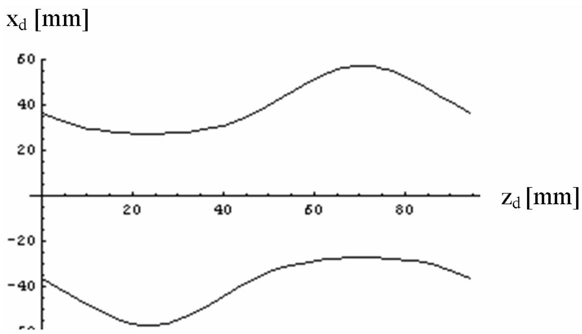

Figure 9. The unfolding of the intersection curve γ_2 of the cylinder C_1

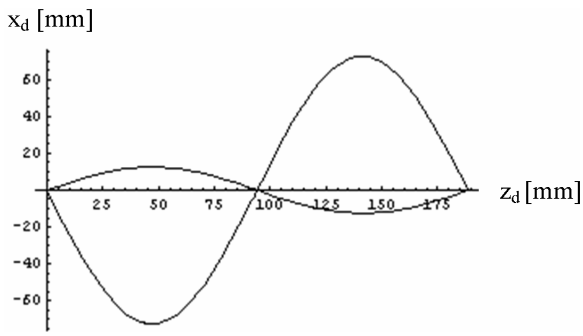

Figure 10. The unfolding of the intersection curve γ_4 of the cylinder C_2

4. Conclusions

The paper presents two methods of determining the unfolding of a connection, used in industry, being useful for design engineers. Which method is more accurate or faster is up to the user. The descriptive geometry method has the advantage that once drew the connection is relatively easy to determine its unfolding, measuring geometrical elements, mentioned in the paper. The disadvantage is that the connection has to be drawn, for each size of diameters, plus the required accuracy of the drawing program.

The mathematical method is faster and is useful when we want to optimize the connections.

References

1. Bucalo, Lucia et al. (1997) *Strumenti e metodi per progettare corso di tehnologia i disegno*. Zanichelli Publisher, ISBN 9788808173003, Bologna, Italy (in Italian)
2. Jänlich, K. (2001) *Analysis für Physiker und Ingenieure*. Springer Verlag, ISBN 9783540419853, Berlin, Germany (in German)
3. Khin, D., Kyu, N. (2002) *Machine drawing*. Yangon Technological University, Available from: www.most.gov.mm/techuni/media/ME01011_96_142.pdf, Accessed: 21/08/2010
4. Canuto, C., Tabacco A., Tabacco Vignati, A.M. (2008) *Mathematical Analysis I*. Springer Verlag, ISBN 978-8847008755, Milan, Italy
5. Popa, V., Petre, I., Costache, I. (2004) *Analytical methods to determine the intersection curves of the cylinders*. Romanian Journal of Technical Sciences, Tome 49, 2004, p. 595