METHODS FOR DETERMINING THE UNFOLDING OF THE PIPES USED IN INDUSTRIAL INSTALLATIONS

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Abstract
The pipes, in their various forms, are found in all the industrial installations and are formed by intersections of corps (cylinders, cones,..). The design, the execution and their installation requires tracing their unfoldings. The paper take into account a theme often found in engineering design of pipes in industrial installations, where determining of the geometric elements, in true size, is their basis of execution, necessary for mounting in installation. This paper resolves with two ways one of these technical applications. This work aims to solve using the classical graphical method of the descriptive geometry and analytical method using the program Mathematica 5.1, the curve of intersection of such a pipe. In figure are presented curves of intersection of the cylinders C1, C2, C3, of equal diameter (D1 = D2 = D3 = 40 mm) which intersect the recipient C, of diameter D = 60 mm. Using the both methods we obtain the same curves of intersection.

Keywords: cylinder, curve intersection, unfolding

1. TECHNICAL CONSIDERATIONS

The pipes, in their various forms, are found in all the industrial installations and are formed by intersections of corps (cylinders, cones,..). The design, the execution and their installation requires tracing their unfoldings.
This work aims to solve using the classical graphical method of the descriptive geometry and analytical method using the program Mathematica 5.1, the curve of intersection of such a pipe.

2. GRAPHICAL METHOD OF DETERMINING THE INTERSECTION CURVES

In figure 1 are presented curves of intersection of the cylinders C1, C2, C3, of equal diameter (D1 = D2 = D3 = 40 mm) which intersect the recipient C, of diameter D = 60 mm.

2.1. Intersection curve γ_3 of cylinders C_2 and C_3

The cylinders C_2 and C_3 have concurrent axes, perpendicular to one another and equal diameters (fig. 2).

The intersecting points of generating pairs coplanar obtain the common curve of the two cylinders.

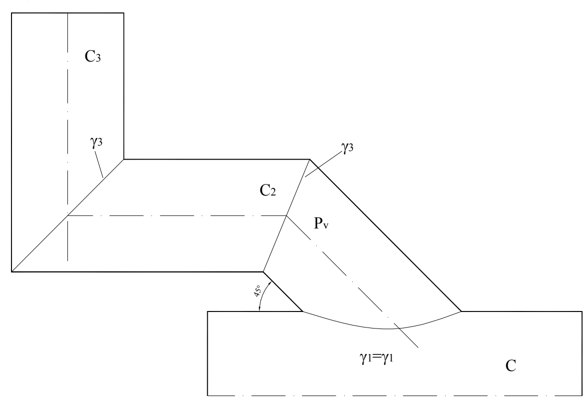


Figure 1. Curve of intersection of the pipes

To obtain the pairs of generators the two cylinders are sectioned with flat front. Such the front plans F_{h1},..., F_{h7}, cut off the cylinder C_3 after the generators from points A (a, a', a”) and B (b, b', b”) and C_2 cylinder after the generators from points 1 and 2. Similarly, the other points of the curve are determined [2].

2.2. Unfolding of cylinders C_2 and C_3

The unfolding of the rotating cylinder C_3 is a rectangle having the size $2\pi R_3 G_1$, where R_3 is the radius of the base cylinder and G_1 its generator (fig.3).

To obtain the unfolding of the rotating cylinder C_2 its basis is considered sectioned with a plane (inclined at an angle of 113^o to the horizontal.

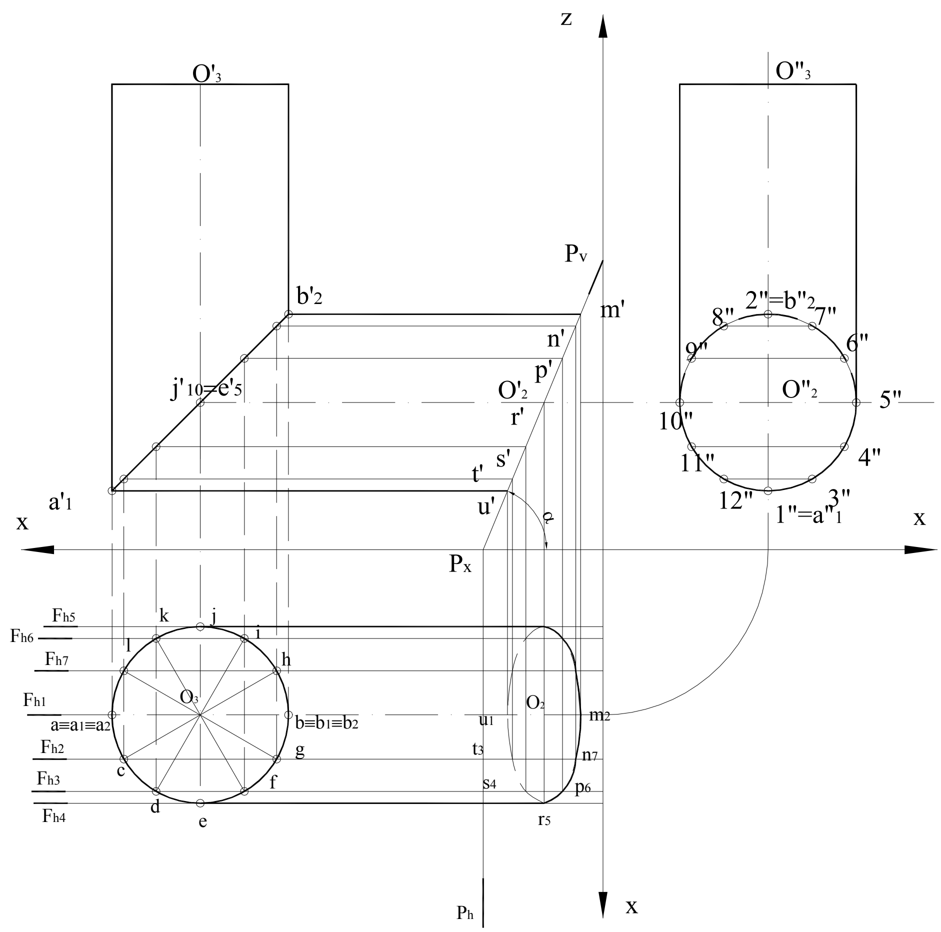


Figure2. Curve of intersection between cylinders C_2 and C_3

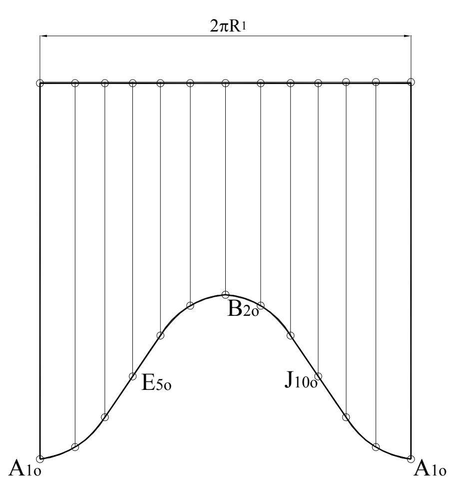


Figure 3. Unfolding of cylinder C_3

The lengths of the generators will be measured in the vertical plane and the length of the unfolding of the cylinder is $2\pi R_2$, where R_2 is the radius of the cylinder C_2 (fig. 4).

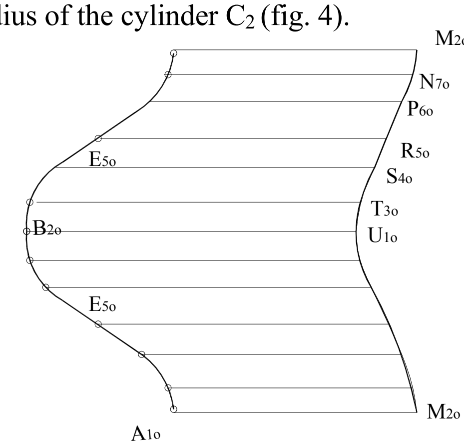


Figure 4. Unfolding of cylinder C2

2.3. Intersection curves γ and γ_1 of cylinders C_1 and C

To establish the curve of intersection between the cylinders C_1 and C tangent plane are going to the oblique cylinder (which is flat limit of the intersection). Between these planes (P_1 and P_7) the front auxiliary planes (P2, ..., P6) are traced.

The intersections of the generators formed of these planes on the horizontal cylinder with the generators formed on the oblique cylinder give the points of the intersection curve (fig.5).

2.4. Unfolding of cylinders C_1 and C

To obtain the unfolding of the cylinder C_1, the curve of intersection above base is given by its intersection with the cylinder C_2 (also obtained by cutting with a plan). The lengths of generators will be measured in the vertical plane, and the length of the unfolding of the cylinder is $2\pi R_1$, where R_1 is the radius of the cylinder C_1 (fig.6).

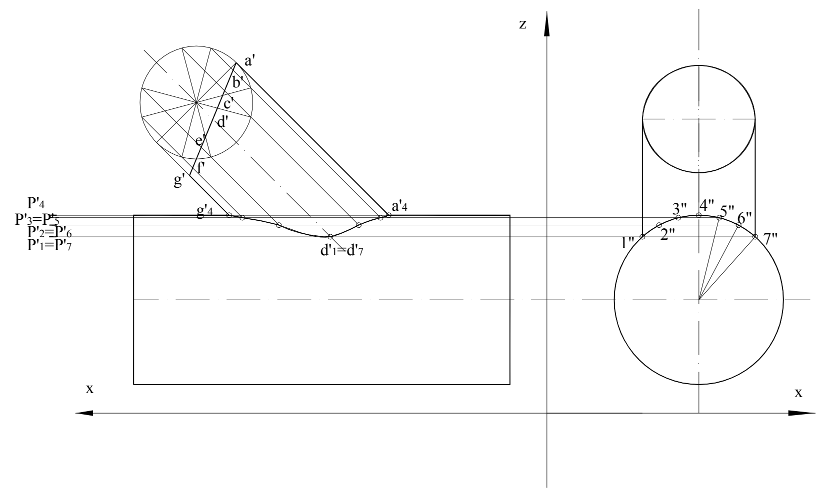


Figure 5. Curve of intersection between cylinders C_1 and C

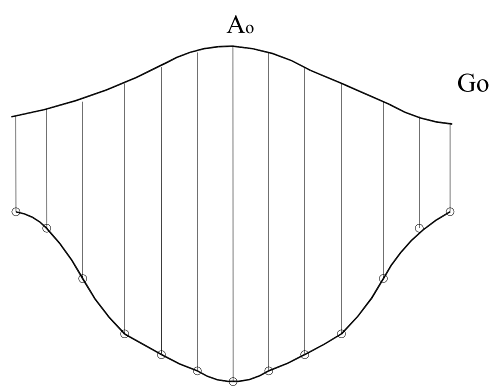


Figure 6. Unfolding of cylinder C1

For the unfolding of the vessel (the cylinder C) the earlier the whole area is unfolded, then perpendicular axes are gone inside the unfolding. The lengths of the arcs, which are obtained from intersection, on one side, are traced and on the other side the length measured from the cylinder axis C1 to the corresponding generators are considered (fig.7).

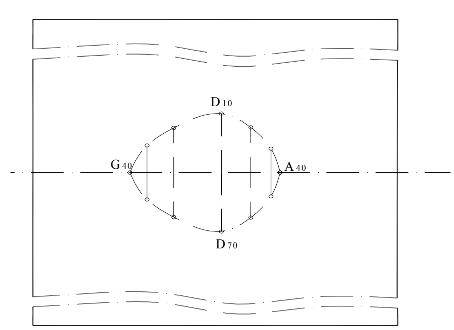


Figure 7. Unfolding of cylinder C

3. METODE ANALITICE DE DETERMINARE A CURBELOR DE INTERSECTIE

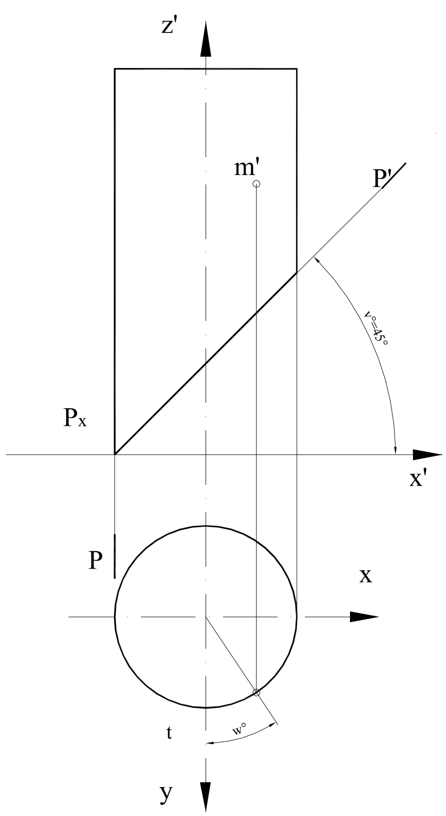
3.1. Intersection curves γ_3 of cylinders C_2 and C_3

For the cylinder presented in the figure 10, the equation of the transformation curve, is obtain by applying the transformation (2), (3) to the equation (1) [1, 3, 4].

$$z = (x+R)\ tg\ V,\ x \in [-R,R] \quad (1)$$
$$x = R \sin W \quad (2)$$
$$z = z_d \qquad \alpha \in [0, 2\pi] \quad (3)$$
$$x_d = R\ W$$
$$x = R \sin (x_d/R)$$
$$z = z_d$$

Those we obtain:

$$z_d = tg\,V\ (R \sin \frac{x_d}{R} + R),\ x_d \in [0, 2\pi R] \quad (4)$$



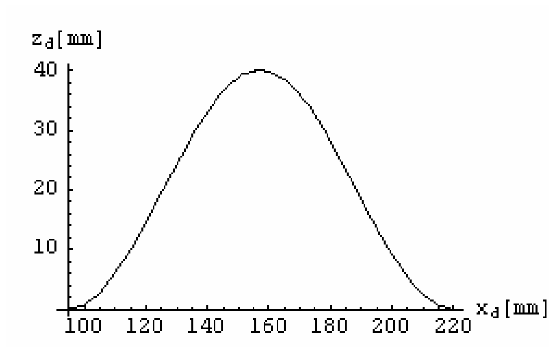


Figure 8. The geometric elements of cylinder C_3

Figure 9. The unfolding of the intersection curve of cylinder C_3

For an angle V = 45° and a cylinder radius R_3 = 20 mm, we obtain the figure 9 and for an angle V = 22,5° and a cylinder radius R_2 = 20mm, we obtain the figure 10, by introducing the relation (4) into Mathematica program.

3.2. Intersection curves γ and γ_1 of cylinders C and C_1

In accordance with figure 11 we take the cylinder C, of diameter D, and its reference system Oxyz and the cylinder C_1, of diameter D_1, and its reference system $O_1x_1y_1z_1$, where $y \equiv y_1$ and $O \equiv O_1$.

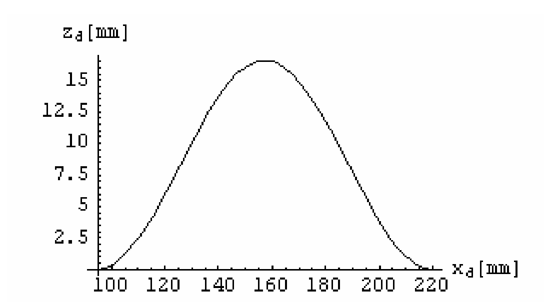


Figure 10. The unfolding of the intersection curve of cylinder C_2

The cylinders equations expressed in the chosen reference systems are:

$$x^2 + y^2 = R^2 \quad (5)$$

$$y^2 + z_1^2 = R_1^2 \qquad (6)$$

The two reference system are rotated, one given another, by the angleφ. The transformation formula of the coordinates, to passing from the system Oxyz into $O_1x_1y_1z_1$ and vice versa is:

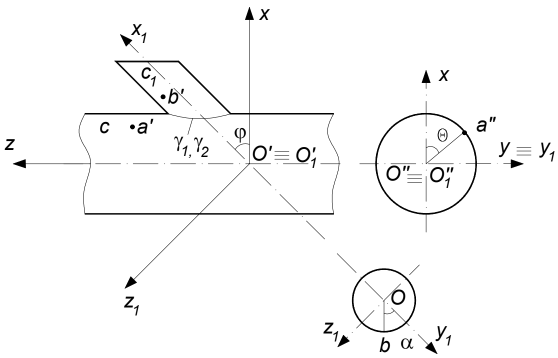


Fig.11. The geometrical elements of cylinders

$$x_1 = x\cos\varphi + z\sin\varphi \qquad (7)$$
$$z_1 = z\cos\varphi - x\sin\varphi \qquad (8)$$
$$x = x_1\cos\varphi - z_1\sin\varphi \qquad (9)$$
$$z = x_1\sin\varphi + z_1\cos\varphi \qquad (10)$$

We relate 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:

$$z^2 - 2x\cdot tg\varphi\, z + \frac{R^2 - R_1^2}{\cos^2\varphi} - x^2 = 0 \qquad (11)$$

The equation of the transformation curve γ_1, border of the cylinder C, is obtained by applying the transformations (12, 13) to the equation (11).

$$x = R\cos\theta = R\cos x_d/R \qquad (12)$$
$$z = z_d \qquad (13)$$

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:

$$z_d^2 - 2Rz_d\cos\frac{x_d}{R}\cdot tg\varphi + \left[\frac{R^2 - R_1^2}{\cos^2\varphi} - R^2\cos^2\frac{x_d}{R}\right] = 0$$

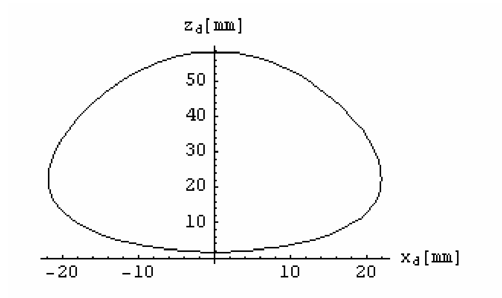


Fig.12 The unfolding of the intersection curve γ of cylinder C

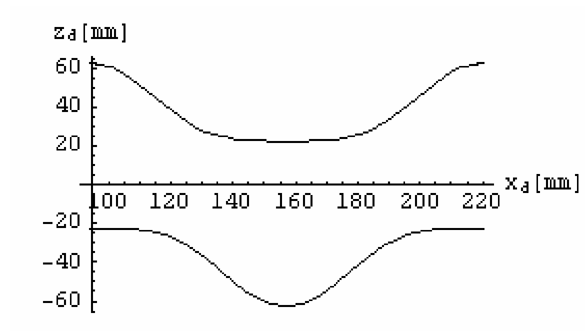


Figure 13. The unfolding of the intersection curve γ_1 of cylinder C_1

Then:

$$z_{d1,2} = R\cos\frac{x_d}{R}\cdot tg\varphi \pm \frac{1}{\cos\varphi}\sqrt{R_1^2 - R^2\sin^2\frac{x_d}{R}} \qquad (14)$$

$x_d \in [-R \arcsin R_1/R,\ R \arcsin R_1/R]$

We obtain the figure 12, by introducing the relations (14) into Mathematica program.

The equation of the transformation curve γ_1, border of the cylinder C_1, is obtained by applying the transformations (15, 16) to the equation (11):

$$x_1 = x_{d1} \qquad (15)$$
$$z_1 = R_1\sin\alpha = R_1\sin z_{d1}/R, \qquad (16)$$

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

The following equation is obtained:

$$x_{d1}^2+2R_1\sin\frac{z_{d1}}{R_1}x_{d1}-R_1^2\sin^2\frac{z_{d1}}{R_1}-\frac{R^2-R_1^2}{\cos^2\varphi}=0 \quad (17)$$

Then:

$$x_{d1}=-R_1\sin\frac{z_{d1}}{R_1}\pm\frac{1}{\cos\varphi}\sqrt{R^2-R_1^2\cos^2\frac{z_{d1}}{R_1}} \quad (18)$$

$$z_{d1}\in[0,2\pi R_1] \quad (19)$$

The figure 13 is obtained by introducing the relations (18, 19) into Mathematica program.

3. CONCLUSION

Using a several mathematical methods in descriptive geometry, we can obtain the same results.

4. REFERENCES

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