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GEOMETRIC SHAPE – A DESIGN CREATIVE RESOURCE

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Abstract: *The aim of this paper is to broach the part of the geometrical shapes in designing the industrial products. Beginning with elementary geometrical shapes (cylinder, cone, sphere, etc.) by operations of geometrical transformation (rotations, translations, etc.) and by dividing them into sections or unwinding, new and complex shapes can be obtained having geometrical and functional properties differing from the ones of the initial shapes.*

Key words: *industrial design, geometrical shape, functional shape, technological shape.*

1. INTRODUCTION

"Imagination is more important than knowledge" said Albert Einstein. Whether Albert Einstein was right cannot be told for sure but it is obviously that imagination appears faster when the man hold a lot of knowledge in a field.

Living in the nature the man observed what happened around him: the whirlpool, the design of the shell and his own ear, spider's web etc, all those having in common the helix and spiral known since Neolithic. Today, the helix and spiral are used in many technique constructions: plane and spatial cams, springs, threads, conveying spirals, cutters, architecture stairs etc. This example highlights as clear as possible the inexhaustible resource given by a very old but not obsolete science, namely Geometry [4, 8].

As a part of mathematics not contradictory to mathematical analysis or algebra but strong connected to them, the geometry holds the power of creation and synthesis in techniques and arts. It offers information on the known plane and spatial shapes, relations among them, their geometrical transformations, plane and spatial structures that can be achieved by using these shapes as well as properties and possibilities offered by them [6].

Descriptive geometry as a part of geometry is the base of engineering designing, the universal language of the technical creation process. It develops intuition and spatial imagination and represents the scientific base of the technical drawing [3, 5].

The concept of shape appears in almost all definitions for Design, given by different trends, schools or personalities [1, 2].

Design is a creative activity that consists in setting out the shape properties of the industrially made objects. The object shape properties includes not only exterior characteristics but also all the structural relations that make a coherent unity from an object or objects system, regarding the viewpoint of both the producer and the end user. (I.C.S.I.D. – The International Committee of the Societies of Industrial Design).

2. GEOMETRIC SHAPE AND PRACTICAL APPLICATION

Below it is an example, which shows the way from the geometry shape to the practical application (Fig. 1).

The followings are proven:

a. The plane section in the rotation cylindrical surface is an ellipse;

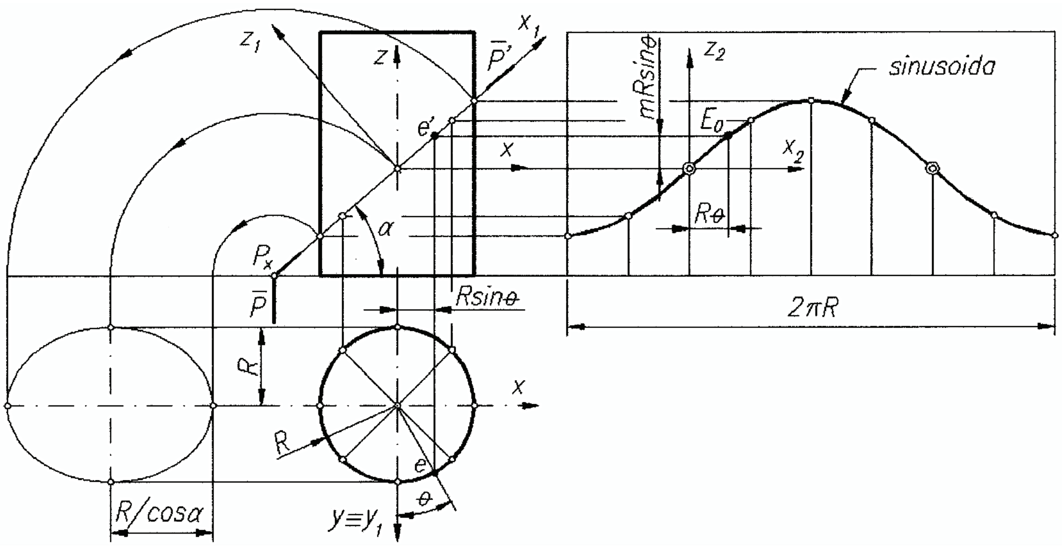

Fig. 1. The unwinding transform of a plane section curve in a straight circular cylinder.

b. The unwinding transform of an ellipse in a sinusoid. The cylinder equation is:

$$\begin{cases} x^2 + y^2 = R^2 \\ z = z. \end{cases} \quad (1)$$

The equation of the [P] plan is:

$$z = x \cdot \mathrm{tg}\alpha . \quad (2)$$

The space ellipse equation is:

$$\begin{cases} x^2 + y^2 = R^2 \\ z = x \cdot \mathrm{tg}\alpha. \end{cases} \quad (3)$$

An α angle rotation around the y axis of the Oxyz system leads to the plan ellipse equation ($x_1 = x/\cos\alpha$; $y_1 = y$; $z_1 = 0$), so:

$$y_1^2 = (x_1 \cdot \cos\theta)^2 = R^2, \quad (4)$$

or:
$$\left(\frac{x_1}{R/\cos\alpha}\right)^2 + \frac{y_1^2}{R^2} = 1. \quad (5)$$

The coordinates of E_0 on the unwinding are: $x_2 = R\cdot\theta$; $z_2 = R\cdot\sin\theta\cdot\mathrm{tg}\alpha = m\cdot R\cdot\sin\theta$, where $m = \mathrm{tg}\alpha$ = constant.

At the end:
$$z_2 = m \cdot R \cdot \sin\frac{x_2}{R} . \quad (6)$$

with $x_2 \in [0, 2\pi\cdot R]$.

The applications of the plane section (ellipse) in the rotation cylinder are shown hereinafter:

- Joining the equal diameters pipes to plane (Fig. 3) or spatial (Fig. 4) elbows. If sections T are cut from the pipe in Fig. 2 and are rotated successively by 180° it can be obtained the plane elbow (Fig. 3) or an approximate built-up barrel segment. In order to achieve the spatial elbow in Fig. 4, the connection ellipses between sections are not in mirror any longer but rotated by a φ angle, that is before cutting the pipe after the E_2 ellipse this is rotated by the φ angle;
- Precise cutting out of small thickness sheets (0.2–0.5 mm) to a sinusoid, sheets used at joining, piping etc;
- Achieving plane coverings with different sinusoidal shapes and in desired colour ranges and textures by joining the cylindrical sections and rolling them on a plane surface (Fig. 5);

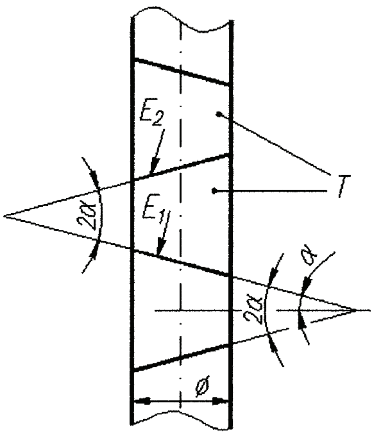

Fig. 2. Cutting section from a cylinder.

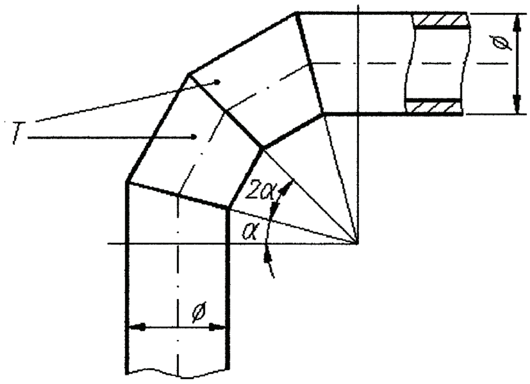

Fig. 3. Joining the equal diameters pipes to plane elbows.

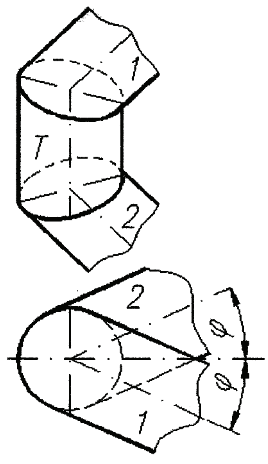

Fig. 4. Joining the equal diameters pipes to spatial elbows.

- Elliptical patterns of different sizes obtained by cutting up from cylindrical bar are made much easier than by copying [6, 7].

In the above mentioned example there has been used: concepts of plane and spatial geometry; analytical geometry (calculus relations); descriptive geometry (projections, swinging, rotations, unwinding); elements of graphics engineering (drawings, dimensions) and there were set out relations among cylindrical sections, structure and their layout aiming to practical applications.

All these together with manufacturing technology – sections cutting, chamfering, welding and their assembling – represent design activities namely designing and making a product useful and aesthetic at the same time [8].

Giving the rotation cylinder in Fig. 6, with the base circles C_1 and C_2 connected to the G generators inextensible by spherical joints [7].

By rotating the C_1 circle, the generators will be in a new position (Fig. 7). The cylinder turns into a rotational hyperboloid with a sole web.

The height of the hyperboloid in Fig. 8 is found to be decreased to the one of the initial cylinder by the h height ($G = AB = a'b'$).

The h movement of the C_1 circle is found to depend on the H and R constant cylinder parameters and the angle $2\cdot\alpha$; $2\cdot\alpha \in (0, \pi)$.

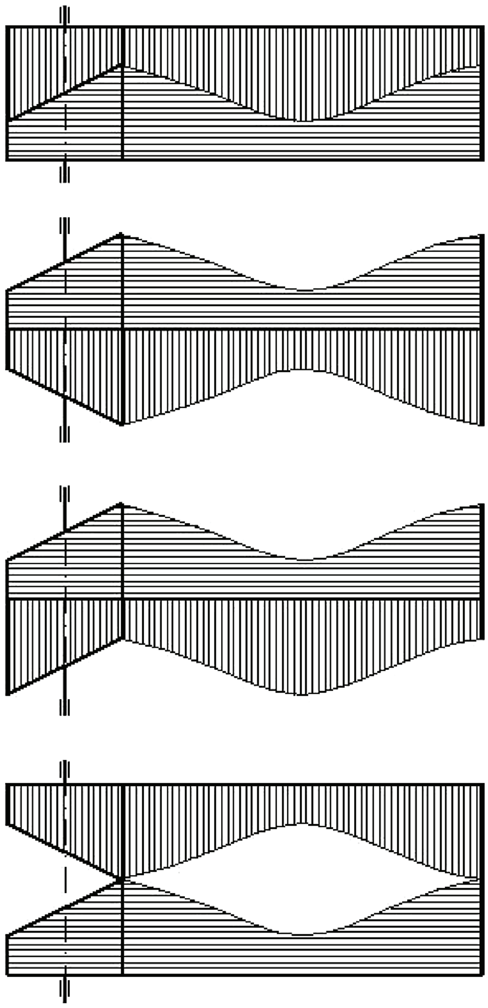

Fig. 5. Achieving the plane coverings with different sinusoidal shapes and in desired color range and texture.

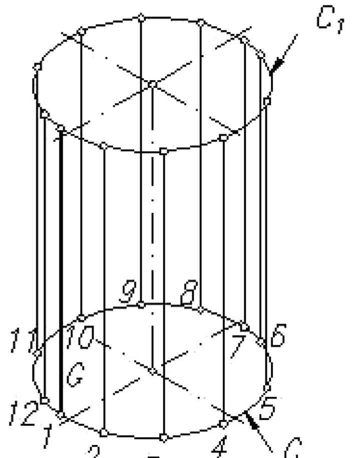

Fig. 6. Deformable cylindrical structure for generating the rotational hyperboloid with a sole web.

To become simpler, it has been considered a new generator position – a front segment. From the right-angled triangle $b'e'a_1'$ it is written:

$$b'e'^2 = b'a_1'^2 - e'a_1'^2. \tag{7}$$

or:

$$(H - h)^2 = H^2 - 4 \cdot R^2 \cdot \sin^2\alpha. \tag{8}$$

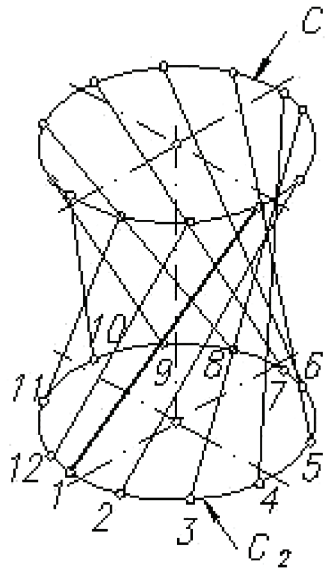

Fig. 7. Sole web rotational hyperboloid obtained from the rotation cylinder, by the relative rotation of bases.

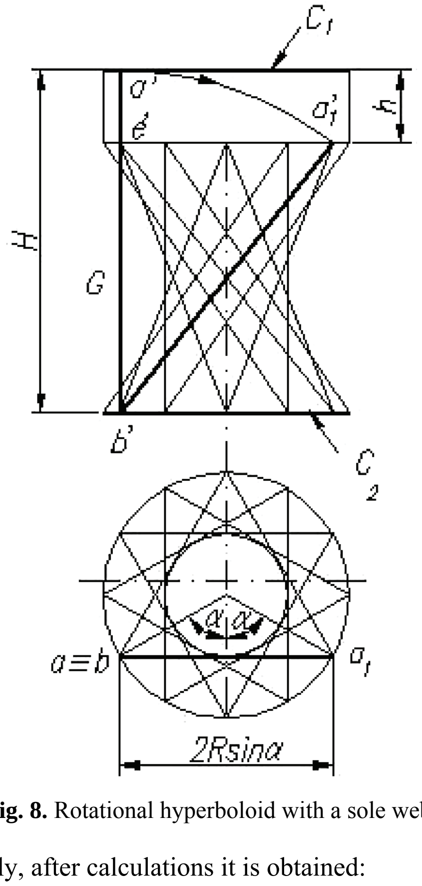

Fig. 8. Rotational hyperboloid with a sole web.

Finally, after calculations it is obtained:

$$h = H - \sqrt{H^2 - 4 \cdot R^2 \cdot \sin^2\alpha}. \tag{9}$$

If $\alpha = 2 \cdot \pi \Rightarrow h = H - \sqrt{H^2 - 4 \cdot R^2}$ the cylinder becomes cone provided that $H > 2 \cdot R$.

As practical applications of this example, we can mention:

- Linear and angular movement mechanism made of several hyperboloid sections connected among them. It is used for step robots – it helps the robot to lift its legs in order to walk;

- The decrease of a fluid flow till closing its passing through an elastic pipe can be achieved by turning a bunch of textile threads fastened around the pipe (like the generators of a cylinder) on two metal plates (see the C_1 and C_2 circles in Fig. 8) and transforming the cylinder segment into a hyperbolical one with changeable passing section depending on the plates rotation angle, respectively the loop circle diameter [6];
- Clamping, pressing, grasp mechanisms when the hyperboloid generators are steady bars attached to the C_1 and C_2 circles in Fig. 8. By rotating one of the plates (the other remains stationary), the bars came near and create pressing forces at the level of the loop circle. Also, by rotating and moving one of the plates, axial forces can be created in a way or another (the cylinder can became a hyperboloid and the distance between plates decreases or the hyperboloid can be transformed into cylinder and distance between plates increases);
- Wheels, rotors, adjusting abrasive or cutting tools based on the hyperboloid's property to change its profile until becomes cylinder [7].

3. CONCLUSIONS

This paper shows the importance of geometry, generally, and of geometrical shapes, especially, in engineering creation. The primary geometrical shapes but especially their transformations by sectioning, unwinding, wrapping, combining, rotating or others similar operations are an inexhaustible creative resource in the design of industrial products.

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