GEOMETRICAL SHAPE – A DESIGN CREATIVE RESOURCE

D. MARIN, L. RAICU, C. RĂDULESCU *

Scopul acestui articol este de a lărgi rolul formelor geometrice în proiectarea produselor industriale. Începând cu formele geometrice elementare (cilindru, con, sferă, etc.) prin operații de transformare geometrică (rotații, translații, etc.), secționând sau desfăşurând, noi şi complexe configurații, pot fi obținute proprietăți geometrice şi funcționale diferite cu respectarea formelor inițiale.

The aim of this paper is to enlarge 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.), sectioning or developments, new and complex shapes can be obtained having different geometrical and functional properties with respect to the initial shapes.

Keywords: industrial design, geometrical shape, functional shape, technological and constructive shape.

Introduction

„Imagination is more important than knowledge“ said Albert Einstein. Whether Einstein was right cannot be told certainly but it is obvious that imagination appears faster when the man hold a lot of knowledges in a field.

Living in the middle of the nature man observed what happened around him: whirlpool, design of 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, architectural newel stairs etc. This example highlights as clear as possible the inexhaustible resources, of a very old but not obsolete science, namely Geometry.

As a part of mathematics not contradictory to mathematical analysis or algebra but strongly 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

* Prof., Prof., Assist., Dept. of Descriptive Geometry and Engineering Graphics, University POLITEHNICA of Bucharest, Romania

spatial structures that can be achieved by using these shapes as well as the properties and possibilities offered by them.

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.

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

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

Geometric shape and practical application

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

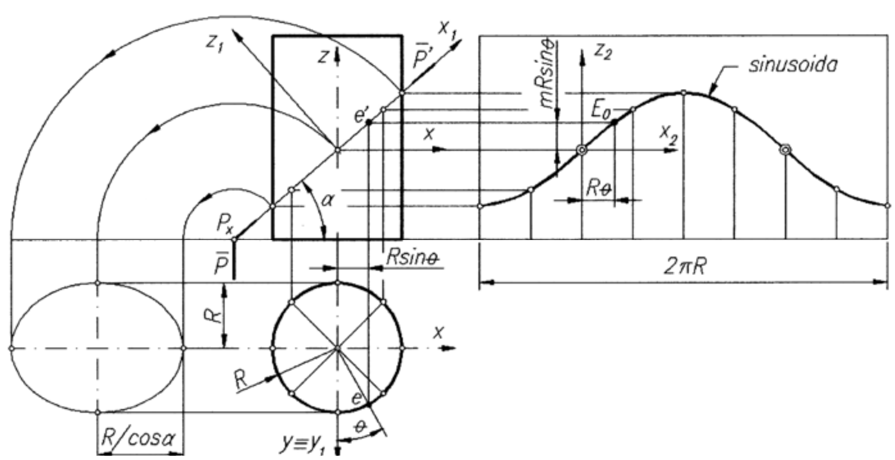

Fig. 1. The development of a plane section curve in a straight circular cylinder

The followings are proved:

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

b. The development of an ellipse in a sinusoid.

The cylinder equations are:

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

The equation of the [P] plane is:

$$z = x \cdot tg\alpha \quad (2)$$

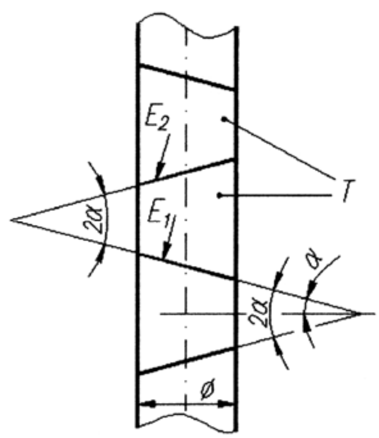

Fig. 2. Cutting section in a cylinder

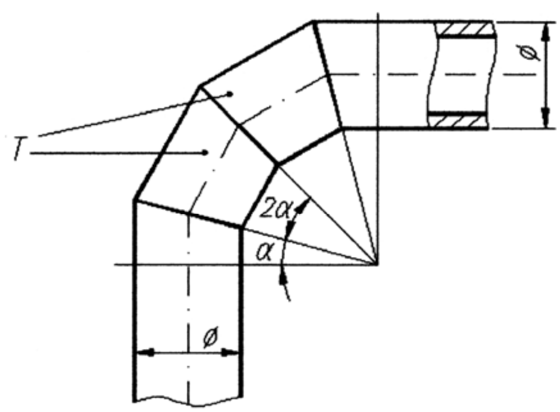

Fig. 3. The plane representation of joining equal diameter pipes by elbows

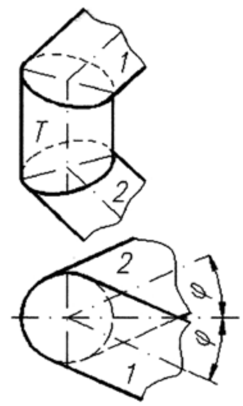

Fig. 4. The spatial representation of joining equal diameter pipes by elbows.

The space ellipse equations are:

$$\begin{cases} x^2 + y^2 = R^2 \\ z = x \cdot \text{tg}\alpha \end{cases} \tag{3}$$

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

$$y_1^2 = (x_1 \cdot \cos\theta)^2 = R^2 \tag{4}$$

or:

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

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

At the end:

$$z_2 = m \cdot R \cdot \sin\frac{x_2}{R} \tag{6}$$

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

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

- Elliptical templates of different sizes, obtained from cylindrical profile by cutting, easier than by copying.

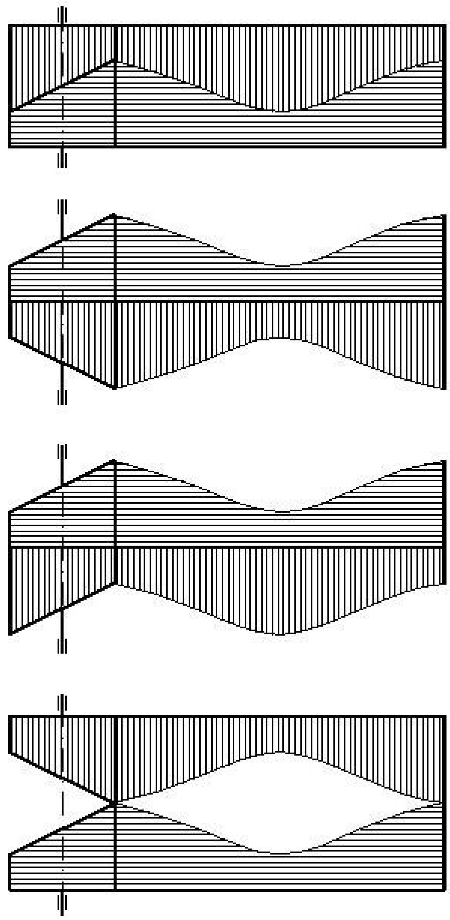

Fig. 5. Achieving plane coverings with different sinusoidal shapes, in desired color and texture ranges

- Joining equal diameters pipes by elbows (Fig. 3) and (Fig. 4). If the segments (frustums) T cut in the pipe from Fig. 2 are rotated by 2α around Ω_1 or by β around Ω_3, the elbow (Fig. 3) is obtained. In order to achieve the elbow (Fig. 4), the connection ellipses between sections are not in mirror any longer but rotated by angle φ.
- Precise cutting out by a sinusoidal of small thickness sheets (0.2 – 0.5 mm) used at joining, piping etc;
- Achieving plane coverings with different sinusoidal shapes in desired color and texture ranges by joining the cylindrical segments (frustums) and rolling them on a plane surface (Fig. 5).

Elliptical patterns of different sizes obtained by cutting up in a cylindrical bar are obtained much easier than by setting off (profiling);

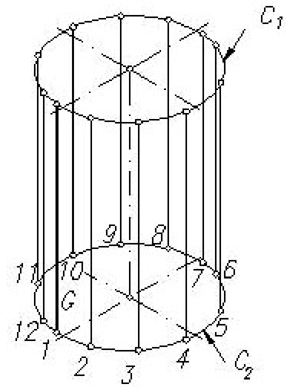

Fig. 6. Deformable cylindrical structure for generating the rotation conoid with a sole napped

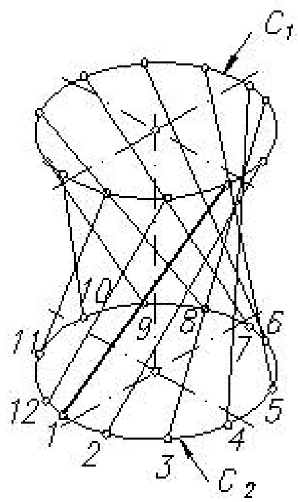

Fig. 7. Sole napped rotation conoid obtained from the rotation cylinder, by the relative rotation of bases by the angle 2α.

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

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

Let's consider the rotation cylinder from Fig. 6, with the base circles C_1 and C_2 connected by ball and socket joints with the inextensible generatrices G.

Rotating the circle C_1 by the angle 2α, the generatrices will occupy a new position (Fig. 7). The cylinder turns into a sole nappe conoid.

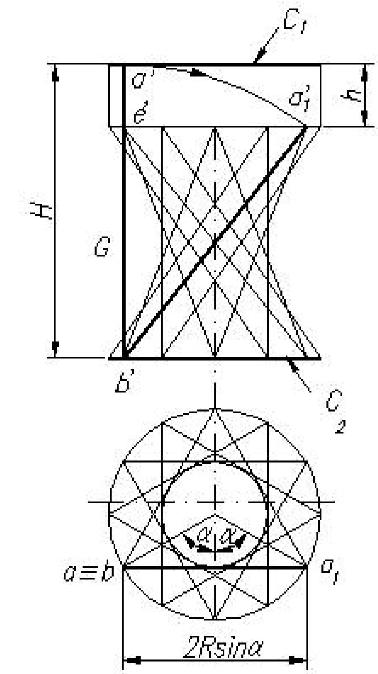

Fig. 8. Rotation conoid with a sole web

The height of the conoid from Fig. 8 is found to be decreased compared to the one of the initial cylinder by the height *h* (G = AB = a'b').

To become simpler, it has been considered a new generatrix position – a front segment. From the right-angled triangle b'e'a$_1$' we have:

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

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

Finally, after calculations it is obtained:

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

The displacement size h of the circle C_1 is found to depend on the *H* and *R* constant cylinder parameters and on the angle 2·α; 2·α ∈ (0, π).

If α = π/2 ⇒ $h = H - \sqrt{H^2 - 4 \cdot R^2}$ 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 conoid sections connected between 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 generatrices of a cylinder) on two metal plates (see the circles C_1 and C_2 from Fig. 8) and transforming the cylinder segment into a conoidal one with changeable passing section depending on the plates rotation angle, respectively on the loop circle diameter;
- Clamping, pressing, grasp mechanisms when the conoid generatrices are steady bars attached to the C_1 and C_2 circles from Fig. 8. By rotating one of the plates (the other remains stationary), the bars come 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 become a conoid and the distance between plates decreases or the conoid can be transformed into a cylinder and the distance between plates increases);
- Wheels, rotors, adjusting abrasive or cutting tools based on the conoid's property to change its profile until it becomes a cylinder.

Conclusions

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

R E F E R E N C E S

1. *Ch. Fiell, P. Fiell,* IndustrialDesign A-Z, Taschen GmbH, ISBN 3-8228-6310-6, Köln, 2000
2. *Ch. Fiell, P. Fiel, Design of the 20th Century*, Taschen GmbH, ISBN 3-8228-4078-5, Köln, 2005
3. *A. Dumitrescu,* Design, Editura Printech, Bucureşti, 2000
4. *V.Papanek,* Design pentru Lumea Reală, Editura Tehnică, ISBN 973-31-1019-3, Bucureşti 1997
5. *D. Quarante,* Éléments de design industriel, Polytechnica 2e édition, ISBN 2717842330, Paris, 1994
6. *Dumitru Marin, ş.a.* Grafică Inginerească Universitatea Politehnica Bucureşti, 1994
7. B. Plăhteanu, V. Belous, *ş.a*. Efectul geometric în creaţia tehnică, Editura „Performantica" ISBN 973-8075-01-7, Iaşi, 2000
8. *Lucian Raicu,* Grafic şi visual între clasic şi modern, Editura Paideia, ISBN 973-596-062-1, Bucureşti, 2002.