Carmen MÂRZA, Georgiana CORSIUC, Octavian POP

METHODS OF REPRESENTING THE DUCTS OF AIR CONDITIONING SYSTEMS

Abstract: *To achieve hygro-thermal comfort in buildings, an essential role belongs to air conditioning installations. Since the thermal agent is the air treated to appropriate parameters, the pipes through which the transport is ensured have large sizes, varying in the range of approximately 100-2000 mm. For this reason, pipe elements need a geometric study, especially where changes in direction, section or shape take place.*
Their representation is mandatory through views and/or sections, i.e. in double or triple orthogonal projections, but for an overall view of the installation are completed with 3D representation, through various drawing programs such as computer aided design.

Key words: *applied geometry; air conditioning ducts, fittings, transition piece, multiview drawing projections, views, sections, 3D representation.*

1. INTRODUCTION

With the development of occupational hygiene concept at the beginning of the 20th century, the ventilation and air conditioning installations began to be widely used in buildings with different destinations: industrial, administration or commercial. Even in residential buildings, located in hot and/or humid climatic areas, this type of installations is used. Moreover, the contemporary man, sensitive to the micro-climate, demands working and living conditions that meet the imposed parameters by the thermal comfort [1].

The ventilation/air conditioning installations use the air as thermal agent, that's involve sections of pipes with large dimensions, having a wide range, respectively about 100… 2000 mm.

Thus, the usual sections are the following types: circular, rectangular (square, rectangle) or flat-oval shape, represented in Fig. 1.

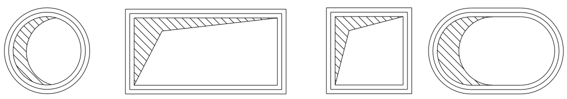


Figure 1 Types of ducts

The last one combines the advantages of the circular or rectangular types, among which, one can mention: the reduced height of the section for the same area compared to the circular sections, respectively, low pressure losses and reduced risk of depositing impurities compared to the rectangular sections [2], [3].

Usually, for design purposes it is necessary to "convert" rectangular or flat oval ducts to round ducts. This substitution is possible by means of the **equivalent diameter** [4]**.** Also, the pressure loss is calculated using **K factor** [5] and **equivalent length** [6] which were presented in a previous paper [7].

The canals are most frequently made of galvanized sheet with a thickness of 0.5-1.2 mm, depending on the size and air pressure, joined longitudinally. The circular or flat- oval ducts can be made also of circular spiral tubing executed on computer numerical control (CNC) machines. For the flat-oval ducts the pressing and the stretching takes place until the desired shape of the cross-section is obtained. The execution technology is chosen according to the type of agent transported through the canals. The use of rubber gaskets gives the tubes a very good sealing.

In previous papers, the authors studied the geometry of the transition parts between circular and flat-oval, rectangular and flat-oval or between flat-oval of different sections, respectively the geometry of different fittings required on the piping route.

Observing the difficulty that students and even designers encounter to understand and represent the routes of ventilation/conditioning installation pipes, the authors emphasize in this paper about the representation methods in 2D and 3D of them.

2. THE REPRESENTATION OF DUCTS ROUTES. EXEMPLES

The authors have chosen two similar routes, but which contain pipes of different sections and shapes.

2.1 Representation of first route

Route 1 is made up of rectangular and circular piping. In this situation, it was possible to use the representation in CADvent, which can draw and dimension the component elements of the ventilation systems developed by Lindab AB, one of the leading manufacturers of spiro duct systems and designer of HVAC solutions [8]. The CADvent database includes the products manufactured by Lindab and the possibility to include other products based on key design parameters.

CADvent plugin for AutoCAD is a toolbox with several helpful features for ventilation designers and contractors. For this software, a license was obtained for use by teachers and students for didactic purposes. CADvent was used to draw the studied duct system using rectangular straight ducts and all necessary components: elbows, Y branch, transition pieces, etc. In this case, parts and fittings can be used directly from the database provided by the program, without requiring a geometrical study of them [2]. In addition, it facilitates the calculation of system characteristics: speed, noise level, required flow rates. In addition, it offers the complete extract of materials in Lindab codes of the designed system, also having a virtual simulation function, with real parameters, for testing the system**.**

2.1.1 Representation of tubing elements

In CADvent the *Rectangular straight duct* dialog box was activated and used to generate the rectangular duct at the appropriate size, as shown in figure 2 [9].

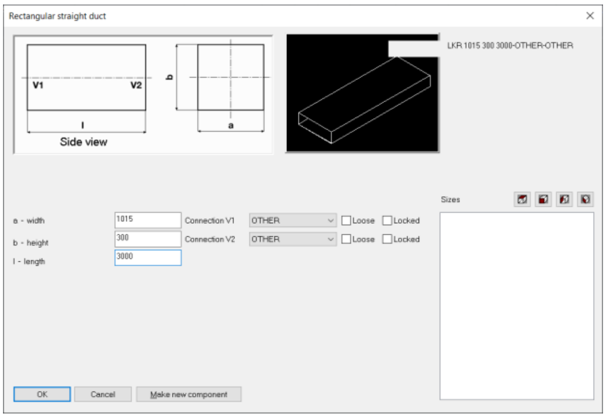


Figure 2 CADvent options for drawing rectangular ducts

CADvent employs simple "drag and drop" methods of generating the entire duct system, including elbows along the duct route. Transition pieces are generated by selecting the two components of different section surface types that are in the vicinity of each other, thus the transition component is drawn automatically.

Similar to the rectangular duct drawing, the **Y branch** dialogue box was opened and used to input all necessary size values to generate the piece, as shown in figure 3.

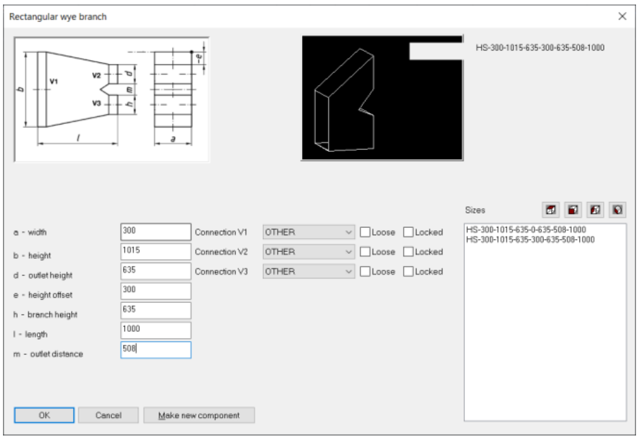


Figure 3 CADvent options for drawing Y Branch component

The final Y branch component generated in CADvent is presented in figure 4.

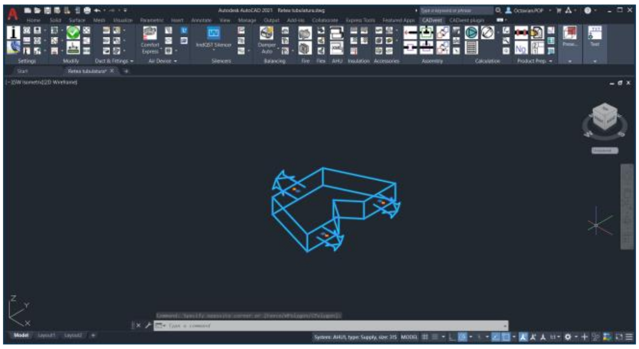


Figure 4 Representation of the Y Branch component

2.1.2 Representation 2D of the route through views

Representation through views is done in agreement with the indications of the ISO/FDIS 128-3: 2020 standard [10], which presents the methods of arrangement of views, cuts and sections. One uses the first angle projection method.

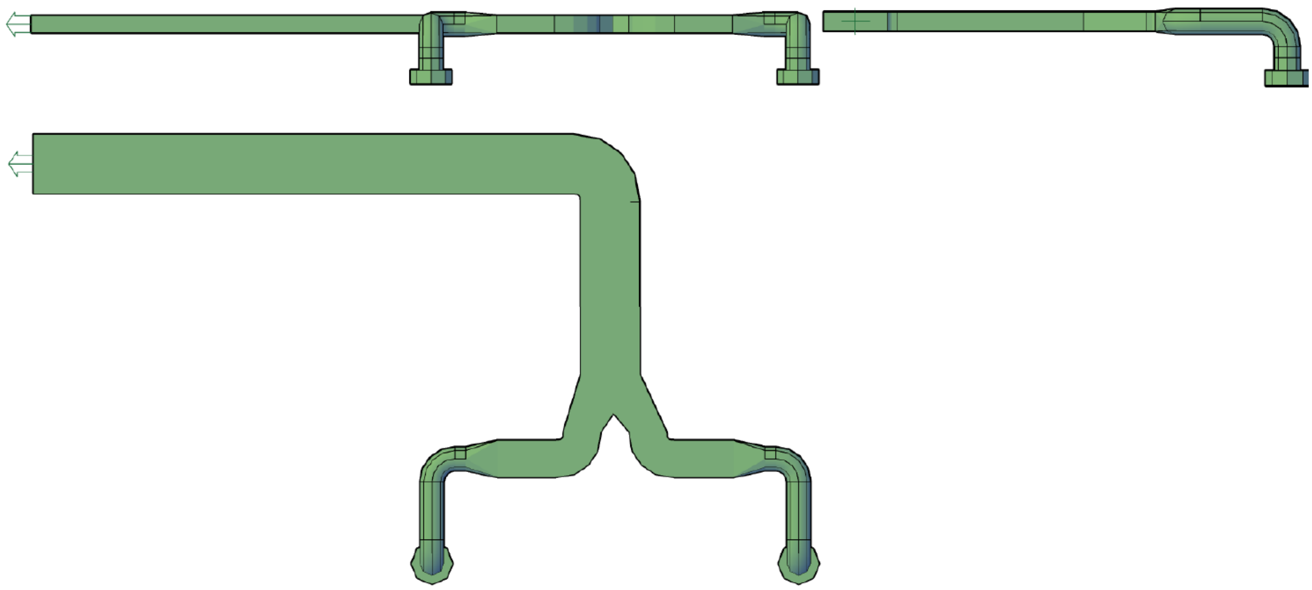


Figure 5 Representation of the first route by views

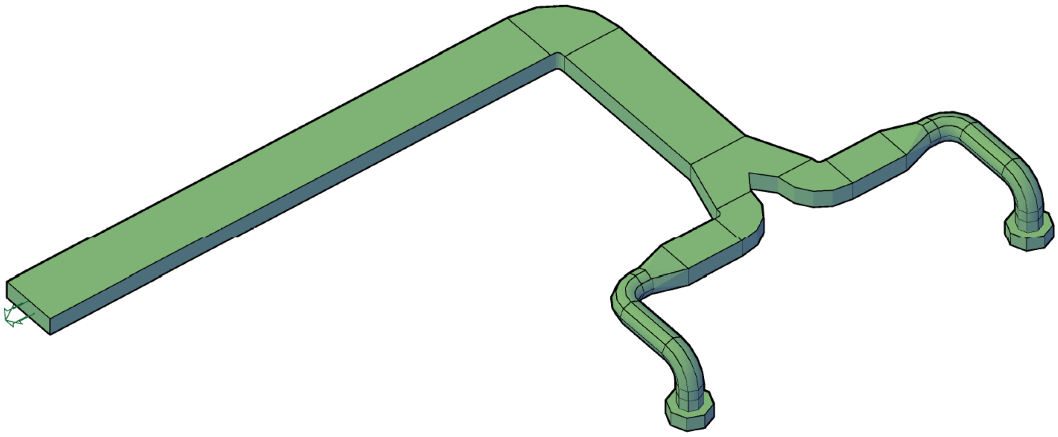


Figure 6 The 3D representation of the first route

One considers that the representation through views is important because they give the true sizes of the objects, while the representation in axonometry (3D) introduces deformation coefficients that differ depending on the type of representation used and which are known from the theory presented to Descriptive Geometry. Also, the dimensioning is much clearer and gives the real sizes - obviously drawn to scale, used in the manufacturing process of the parts.

In Fig.5 are represented the front view, the view from above and the view from left disposed in the previous method mentioned.

2.1.3 Representation in 3D of the first route

Fig. 6 shows the 3D representation of the route given by views from Fig. 5 with the help of the CADvent software [9]. It is confirmed that the understanding of the route is much clearer, not having so many covered (hidden) edges respective overlapping parts.

2.2 Representation of the second route

Considering that most ventilation/air conditioning installations are located in unique buildings, this assumes that the installations themselves are also unique, being repetitive only to a small measure. Thus, Route 2 was chosen using flat-oval and circular section canals. Unfortunately, Lindab discontinued the use of flat -oval ducts, so that in the latest version of CADvent there is no longer the possibility of selecting this type of canal. But, due to the advantages that this type of piping presents, it is still used both in design and in execution.

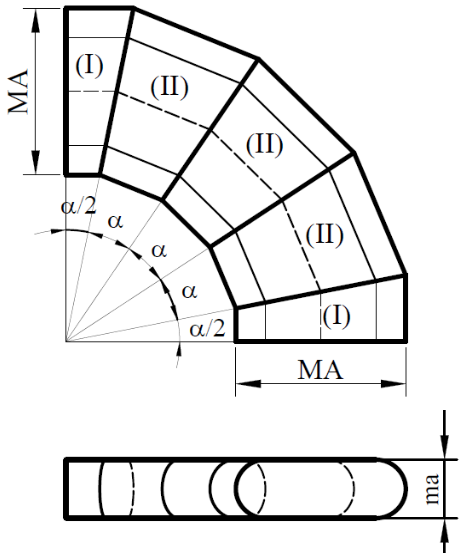
In this case, the three-dimensional representation of the second route was made in AutoCAD 3D. The program does not have so many drawing and design facilities for the field of installations, but it is a program for which the university benefits from the license. In this case, a geometric study of the special parts and fittings is necessary.

2.2.1 Representation of special pieces

On the route of the ventilation/conditioning ducts having a flat-oval section it is necessary to provide parts for changing the direction such as elbows, branches or transition pieces. In the following, the parts used in example 2 were represented.

These pieces are made in specialized manufacturers. To have high efficiency and flexibility in the production process, as far as possible, they are composed from modules, which are assembled as required.

In Figure 7 a **hard bend elbow** is represented, respectively in Figure 7a it is represented in double projection and in Figure 7b it is represented in axonometry, using AutoCAD 3D. The hard bend has the axis of the piece contained in a horizontal plane.



a.

b.

Figure 7 Hard bend elbow

The given solution represents a 90º elbow consisting of five segments: two equal end segments (noted I), having the angle between the limiting vertical projecting planes of 11.25º and three identical intermediary segments (noted II), having a 22.5º angle between the limiting planes [7], [11].

In the Figures 8 and 9 the developments of the two types of segments were represented, including the true size of the sections composed of flat areas and elliptical parts [7]. The elliptical area is similar to the circular cross-section as the angle between the vertical projecting planes is lower.

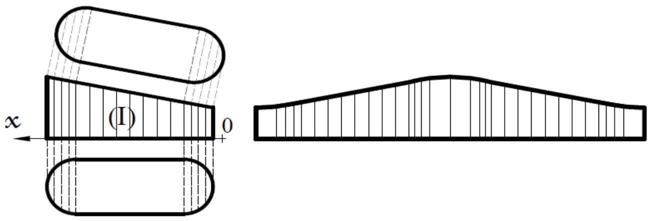


Figure 8 The double projection and development of type I segment

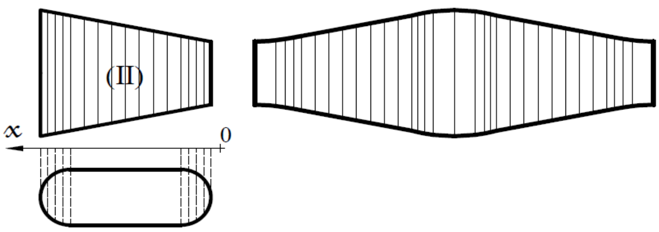
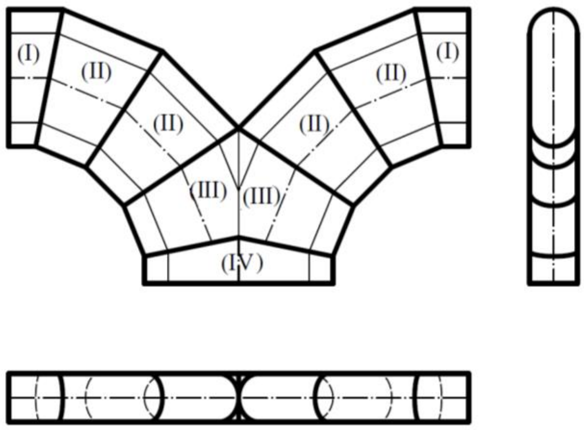


Figure 9 The double projection and development of type II segment



a.

b.

Figure 10 “Y” branch

In Figure 10 an **Y branch** is represented, used when the main pipeline route divides in two directions [1]. Usually, the secondary sectors transport reduced air flows. The piece was represented in orthogonal projection on three planes (Figure 10a), respectively in 3D representation (Figure 10b). It was selected the solution consisting in four types of segments, respectively type I and II used at the hard bend elbow and two other types of segments noted III and IV, whose developments are represented in Figures 11 and 12.

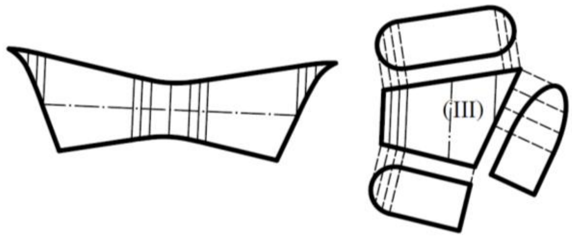


Figure 11 The representation and development of type III segment

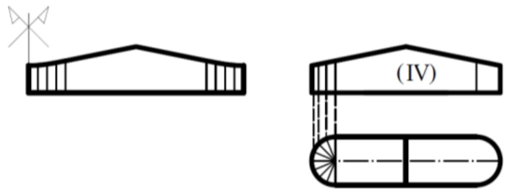


Figure 12 The double projection and development of type IV segment

In many situations in practice, as in one of the examples that we will represent in 3D, it is necessary to change the flat-oval section of the duct to a circular section.

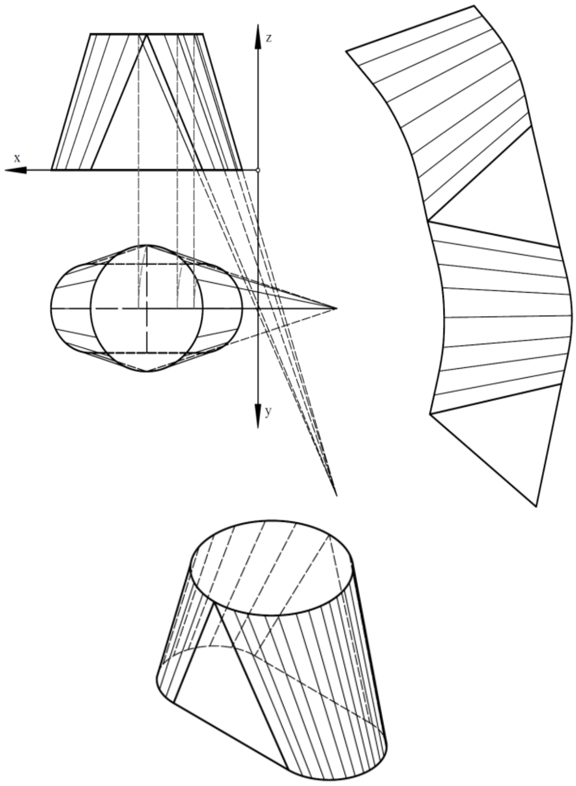


Figure 13 Transition piece between the circular section and the flat-oval section (D > h)

In figures 13 is represented a **transition piece** between circular and flat-oval section in orthogonal projections, the development of the piece [12] and the axonometric representation. The solution is not unique, but it is preferred by the authors, because it ensures air flow with less turbulence.

In this case the development is composed by triangles and truncated cone (frustum of the cone) [12]. To solve it is necessary to determine the vertex of the cone from which the frustum was obtained [13]. For the true length of the generatrices, a rotation was made around the vertical axis through the cone vertex, from which the length of the generatrices of the frustum was taken.

2.2.2 Representation in 2D of the second route

In Fig 11 the second route is represented by views disposed (arranged) through the first angle method.

2.2.3 Representation in 3D of the second route

In Fig. 12, with the help of the AutoCAD 3D software, the second route composed of oval and circular flat canals is represented. The 3D model was generated based on the 2D sketch of the flat oval flow section and the axis, drawn at the appropriate size [14].

3. CONCLUSIONS

In this paper, the authors propose to support students and debutant designers in the field of ventilation and air conditioning installations. This field especially requires the ability to move from 2D to 3D representation and vice versa.

Of course, drawing software are constantly changing and improving, and that is precisely why it is necessary for specialists in the field of building services to understand the geometric reasoning that is the basis of these programs.

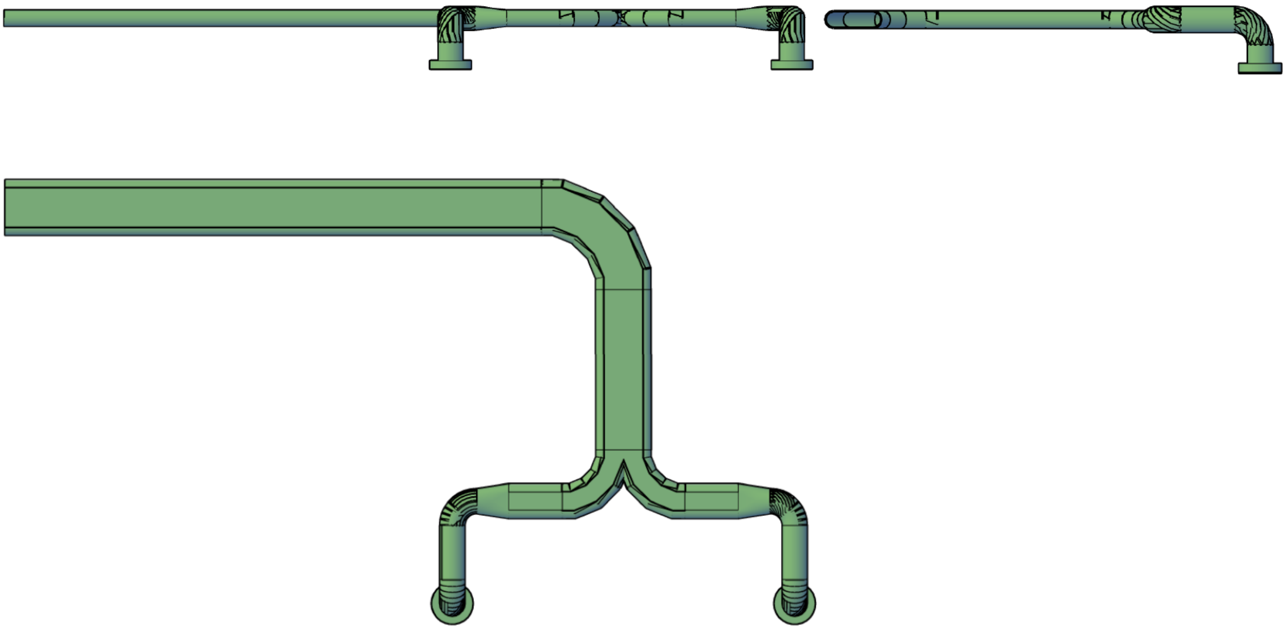


Fig 11 Representation of the second route by views

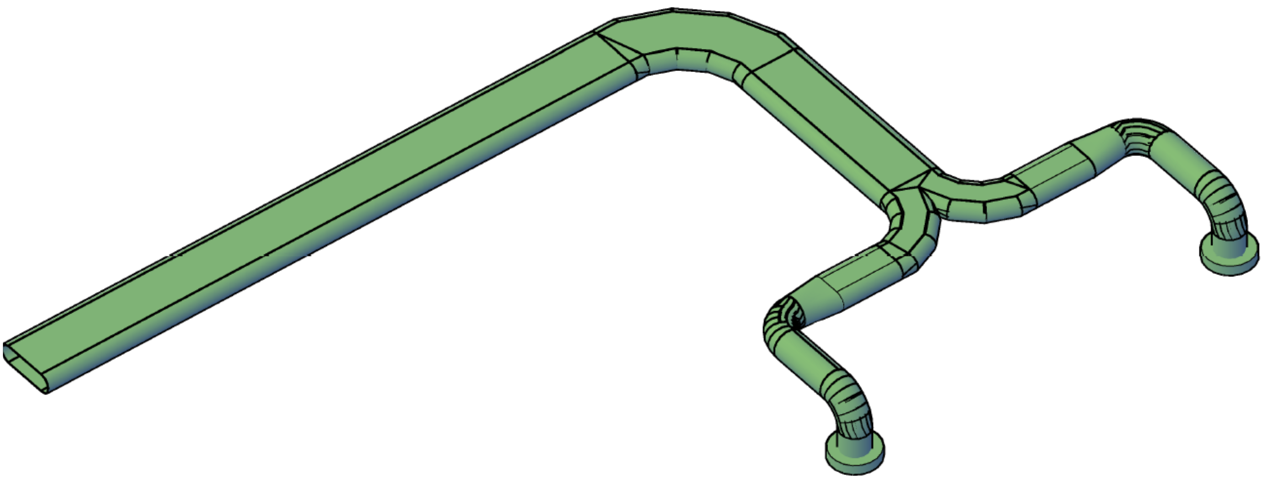


Fig. 12 The 3D representation of the second route

The authors considered important to study the flat-oval ducts and the corresponding fittings, since in Romania and even in Europe these were not widely implemented. These types of ducts were introduced in the design handbooks of the last years without carrying out a hydraulic and geometric study of them. For this reason, these have not been implemented either, as it happened in countries from America and Asia, which recommend and use them due to the advantages offered. Of course, their construction, which is carried out on computer numerical control machines, prior involve a more elaborate geometric study, which requires the application of some knowledge of descriptive and surface geometry, especially in fittings manufacturing.

The solutions presented in the paper are not unique. When selecting the solution, this is taken into account to ensure an air flow with reduced turbulences.

Specialists who work in the field of architecture and civil engineering - construction and building services understand the need to work on BIM (Building Information Modelling) platforms, so that any changes that occur to a project are automatically updated and the participants are informed in real time. In this sense, the use of programs (Revit, Allplan) that allow this becomes a necessity. Also, the use of artificial intelligence will help the designers in their projects due to its ability to manage a huge data base and considerable processing power.

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Author(s):

Assoc. Prof. Ph.D. Eng. Carmen MÂRZA, Technical University of Cluj-Napoca, Department of Building Services, E-mail: Carmen.Marza@insta.utcluj.ro

Lecturer Ph.D. Eng. Georgiana CORSIUC, Technical University of Cluj-Napoca, Department of Building Services, E-mail: Georgiana@mail.utcluj.ro

Lecturer Ph.D. Eng Octavian POP, Technical University of Cluj-Napoca, Department of Building Services, E-mail: Octavian.Pop@insta.utcluj.ro