

Abstract

In the last years the role of sections has been grown significantly thanks to solid modelling. Earlier objects were defined by 2D drawings, while cuts or sections were only used for representing their inner parts in case of need. After a short review of types and rules of section drawings we discuss the different ways how objects can be defined with their sections using 3D modelling software. Finally we discuss that creating solid objects can be used not only in technical but as well as in medical practise. To illustrate them we show examples for both cases: a pump and a human skull.

Keywords

CAD modelling, section, cut, CT scan, lofted protrusion, swept protrusion, revolved protrusion

1 Introduction

To represent the section of components, dimensioning of internal parts a special cut the section can be used. Section is a representation of a cut which shows the component only in the cutting plane without the outlines behind. Nowadays sections are applied more and more apart from this case, the use of them gets unavoidable. At solid modelling creating models, shapes on the base of it can be one or more well-defined planar sketch which is a section. Use of sections appear also in solid imaging methods, such as in the case of CT (Computer Tomograph). For example in the course of a skull CT the real solid shape can be reconstructed by sections made at proper density (Ficzer, 2014).

In the course of additive manufacturing methods sections are also applied. In this case we choose an appropriate reference plane. Then parallel with the chosen reference plane we create the layers with a given thickness. Finally we build up the part from layers. This method develops extremely rapidly, because it is suitable for create quick and cheap molding forms moreover it is suitable in case of certain geometric shapes when other technologies are not usable for production (Ficzer and Borbas, 2009; Ficzer et al., 2013).

2 Cuts, sections

2.1 Cuts

The aim of cuts is to represent the interior of an object instead of dashed lines. Machine drawings sections are mostly made by a parallel plane to any of the reference planes (Ivanco et al., 2016). In most cases cuts can be drawn without specific editing methods, just by approach but rules of descriptive geometry must be observed.

The explaining figure of deriving the simplest technical drawing sections can be seen on the left side of Fig. 1. The tube was cut by S1, S2, S3 planes separately which are parallel to K1, K2, K3 image planes. The part in front of the cutting plane was imaginary removed and the remaining part was projected on the image planes.

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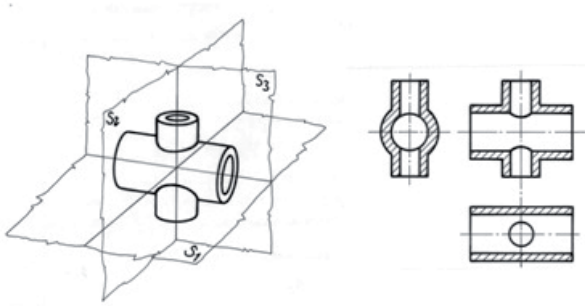


Fig. 1 Generation and technical drawing representation of cuts

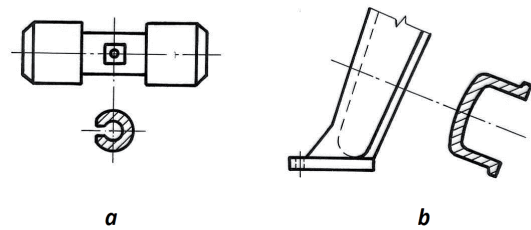


Fig. 3 Only section outside of views

2.2 Sections

Application of them in technical drawings is quite common and useful, it is usually used when some part could be dimensioned on a separate projection (Molnar et al., 2016). In this case the outlines behind the cutting plane would be not only an unnecessary drawing work, but it would worsen the overview of the drawing.

Sections can be drawn within the contours of the view revolved by 90 degrees around the cutting plane, this is called revolved section. It shall be drawn with continuous narrow lines and the cut surface shall be hatched. Neither the cutting plane nor the section shall be identified, see Fig. 2. Indicating the cutting plane even if the section is not symmetric can be omitted.

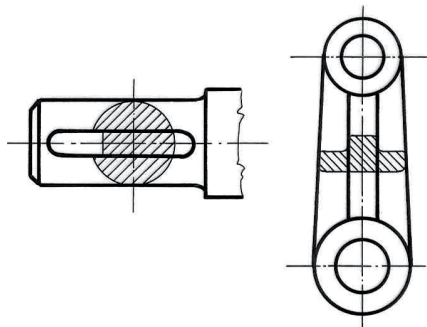


Fig. 2 Revolved only section

Contours of removed sections shall be drawn with thick lines and it can be positioned:

- on a coincident axis with the section lining of cutting plane (Fig. 3a),
- the cutting plane can be oblique to one of the principal image plane (Fig. 3b). In these cases no additional identification is needed.
- with identification of the cutting plane anywhere on the paper. In this case the section lining and the direction of revolving must be marked and the section must be identified with letters but must not be traversed. (Fig. 4)

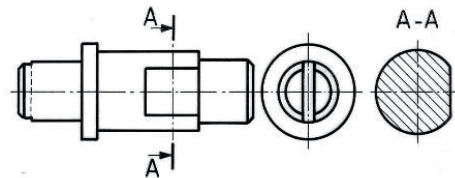


Fig. 4 Cuts can be placed anywhere with signs

Outlines behind the cutting plane shall be drawn only in an exceptional case when a hole or indentation would brake up the section into parts. In this case a continuous contour shall be drawn. See Fig. 5.a.

Drawing feathers of castings can be done simply with local section. See Fig. 5.b.

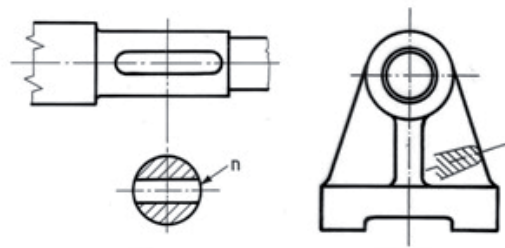


Fig. 5 Section does not fall apart and revolved part section

In case of drawing successive sections the cutting planes must be identified (Lovas et al., 2010). See Fig. 6.

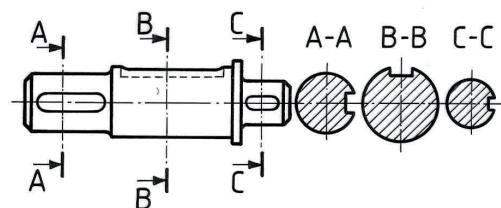


Fig. 6 Successive sections

3 The role of sections in solid modelling

The role of sections has been grown significantly with the appearance of solid modelling. To create a model of a solid object its base is a sort of sketch. These sketches are actually the sections of the object or element in the plane of the sketch. To create the geometry one or more sections can also be used, and the ordinance can be done also in different ways. Some examples are discussed hereinafter.

3.1 Protrusion

This process which is also called extrusion is used in case of creating prismatic geometry. This is one of the most used step during solid modelling.

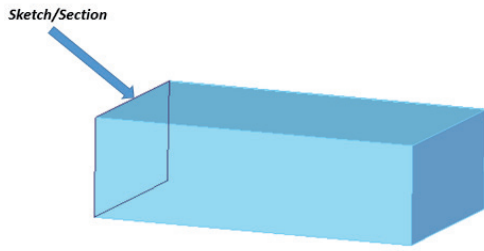


Fig. 7 Protrusion

In its first step the plane of the sketch must be chosen and after the creation of the sketch. By shifting the closed shape perpendicular to sketch plane at a definite distance, swept surface will be get. Material has assigned to the volume which is limited by this swept surface.

3.2 Revolved protrusion

In this case a solid of revolution is created by rotating a two-dimensional figure around an axis. But body of revolution for example a cylinder can be created in other way as well such as protrusion. In the case of revolved protrusion the relationship between of the axis of revolution and the section has a significant role.

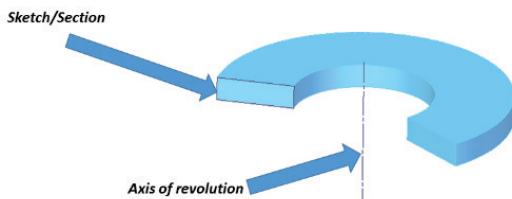


Fig. 8 Revolved protrusion

Figure 8 shows the case when the axis of revolution is parallel to the rectangular section but in Fig. 9 the rectangular section is angled to the axis of revolution. In this way cone surfaces can be created.

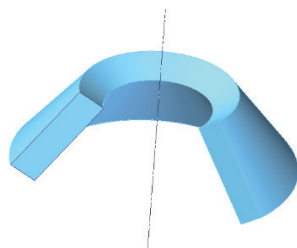


Fig. 9 Revolved protrusion

Also the revolved protrusion can be used for creating torus and ring surfaces when the base is a circle which is rotated around an axis. Such an example can be seen on the next figure.

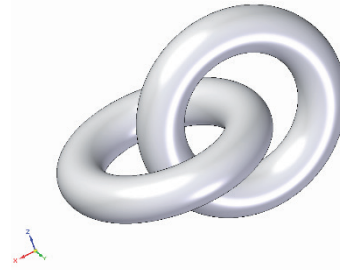


Fig. 10 Revolved protrusion from circle

3.3 Combination of protrusion and revolved protrusion

The discussed processes can be combined of course to create the needed geometry as it can be seen on the next figure.

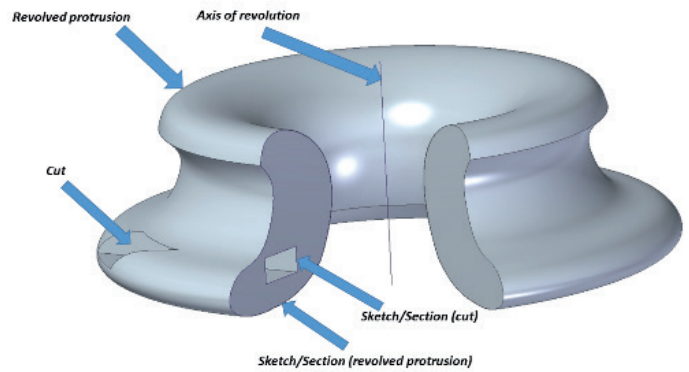


Fig. 11 Combination of cut and revolved protrusion

Naturally, in all cases so far is true that we can operate material removal over the material addition with the help of the given section. This means that the 3D modelling is a representation of Boolean operators. In this case the section defines the shape of deficit.

3.4 Lofted protrusion

Lofted protrusion can be used, when the section of the part is not constant. It means that the cut of it varies depending on its position.

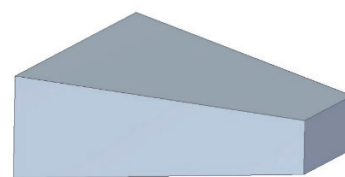


Fig. 12 Lofted protrusion

Planning parts with similar features like this the sections at the ends of transitions shall be defined and as well as the way they wanted to be connected.

3.4.1 Lofted protrusion by parallel sections

First we discuss the case when the sections to be connected are situated parallel at a given distance.

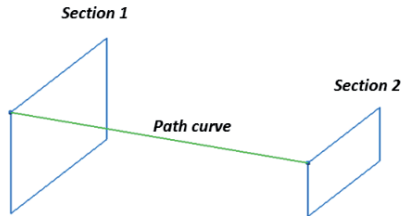


Fig. 13 Components of lofted protrusion

If wrong points are connected to the part will twist as shown in the following illustration.

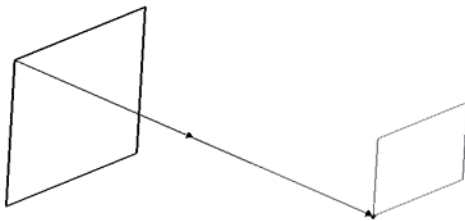


Fig. 14 Creation of twisted state by lofted protrusion

There are cases when the aim is creating a twisted surface for example swirl intake manifold. Such a body with twisted surface can be seen on the next figure.

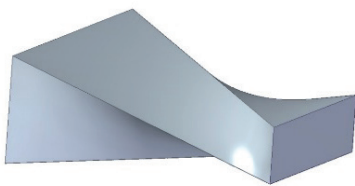


Fig. 15 Creation a part with twisted surface by lofted protrusion

The transition can be done with ordering different sections together, for example a rectangle and circle can be ordered together to generate a shape.

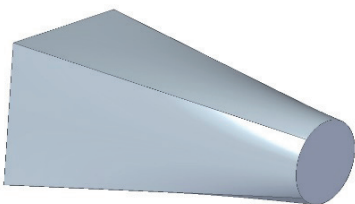


Fig. 16 Lofted protrusion by different nature sections

3.4.2 Lofted protrusion from non parallel sections

Lofted protrusion can be done even the way that the sections which are defining the shape and dimensions of the element are not parallel. Such a case can be seen on the next figure.

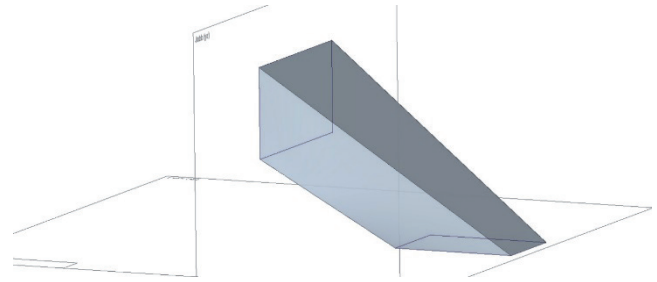


Fig. 17 Lofted protrusion from non parallel sections

3.5 Swept protrusion

Protrusions discussed in the previous chapter had a common feature that their cuts and sections were connected with straight lines. But in practise in many cases much more complicated shapes are needed. If the sections are connected not with parallel straight lines but with an optional curve, it is called swept protrusion.

3.5.1 Swept protrusion with single generating curve

A typical case of swept protrusion with one generating curve and one path curve are tubings when usually a constant cross section is driven along on a given line (path curve).

An example of definition of such a line can be seen on Fig. 18 and the resulting shape (surfaces) on Fig. 19.

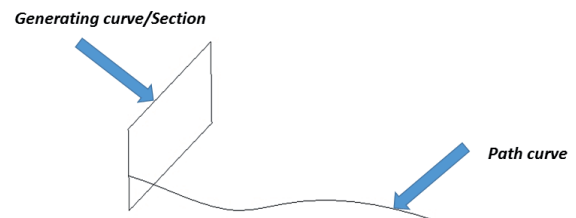


Fig. 18 Components of swept protrusion

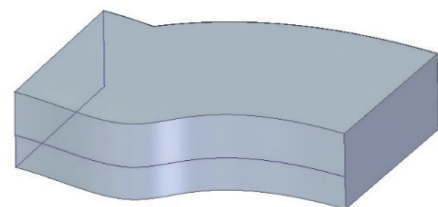


Fig. 19 Swept protrusion with single cross section

3.5.2 Swept protrusion with multiple generating curves

Swept protrusion can be done of course with the use of multiple cross sections so that the wanted geometrical shape could be get.

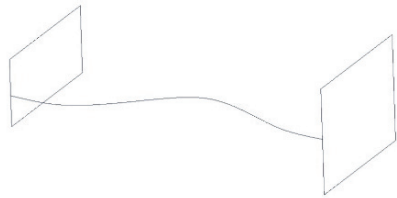


Fig. 20 Swept protrusion with multiple cross sections

But of course the curves in case of swept protrusions are not fully optional, for example a curve must not cross itself.

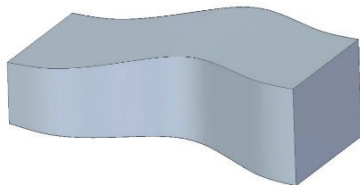


Fig. 21 Result of a swept protrusion with multiple cross sections

As it could be seen previously in case of multiple sections the ordering their points has a significant influence on the final geometry.

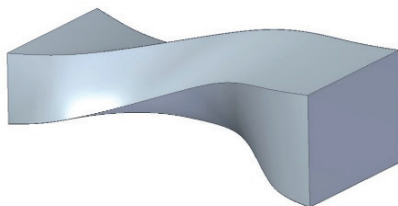


Fig. 22 Twisted swept protrusion with multiple section

Swept protrusion can be also done for example that the position of sections are perpendicular to each other.

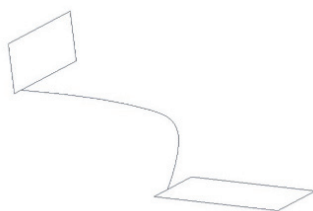


Fig. 23 Swept protrusion with perpendicular sections by a path curve

The realization of it can be seen on the next figure.

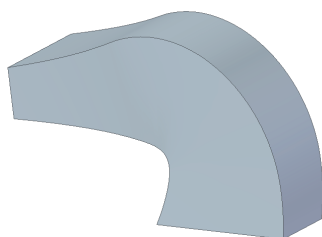


Fig. 24 Resulted body by swept protrusion with perpendicular sections by a path curve

It is important to mention that in case of swept protrusion with multiple generating curves the sections must necessarily join to the path curve otherwise the shape cannot be defined in an exact way. Ordering the equivalent points is in this case also decisive otherwise the surfaces can be twisted.

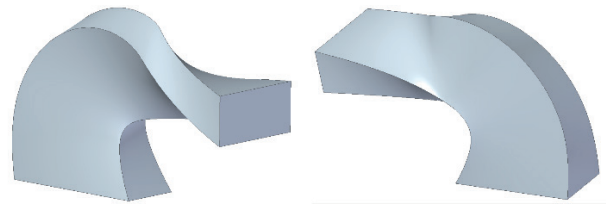


Fig. 25 Resulted twisted body by swept protrusion with perpendicular sections by a path curve

4 Practical applications

4.1 Skull reconstructions by CT scans

For planning an implant to recover a defect on a human skull the solid model of the skull is needed. This solid model can be created by the help of CT scans. The CT scan is actually a section in a given plane. The 3D model of the skull can create from many right ordered high density CT scans by lofted protrusion across different parallel sections.

Such an example can be seen here in after.



Fig. 26 CT scan of a skull in a given plane

On Fig. 26 also a CT scan in a given plane of a human skull can be seen, which can be considered as a cross-section as well. As the cross-section of the skull is not constant, a lot of scans are needed, the more often as possible. Such a series can be seen on the next figure.

It is also important to define the positions of the scans. If we line the scans (sections) in a constant distance from each other the solid model of the skull can be created by the lofted protrusion by different sections. The result of the applied scan series can be seen on the next figure. Of course assign a curve to the border of bones is needed which defines the surface borders unequivocally because in much cases the border of the bony part fades on the scans.

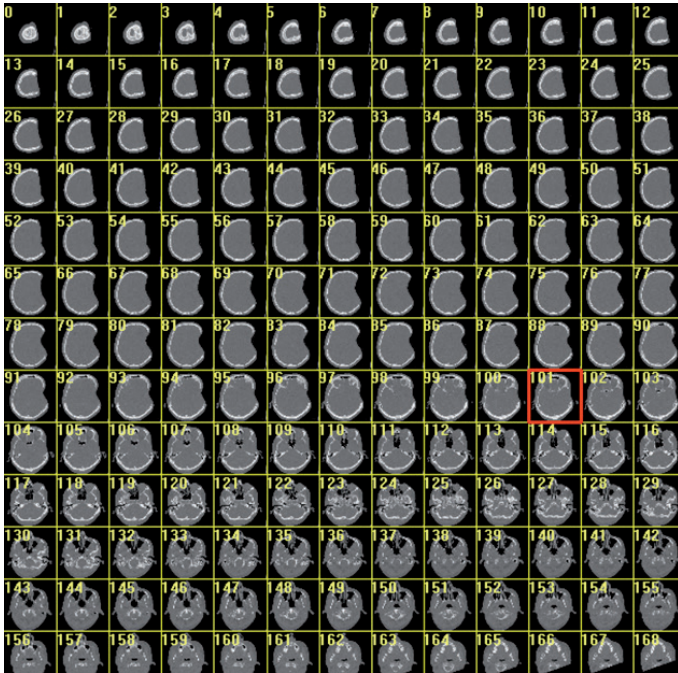


Fig. 27 Series of CT scans



Fig. 28 3D model of a skull

Modelling of the missing part is also based on a similar principle. At a given planar section the section of the missing part can be created.

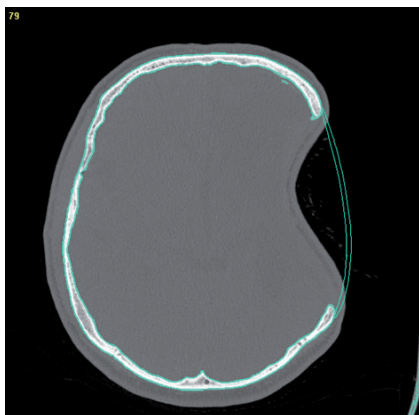


Fig. 29 Section at a given plane

It can be seen on the figure that the implant and the extant part of the skull must join each other suitably. It is important that the planned section and the extant part must join tangentially and in curvature continuously as well if possible because generating a continuous surface is possible only this way.



Fig. 30 Deficit replacement from sections

On the figure above an intermediate state can be seen after ordering an amount of sections to each other. These intermediate states are important during making an implant because it is not possible to order the sections to each other in one step. The reason is as it can be seen on the figure above the position of the sections to each other is not only defined by their distance because it is constant. The mentioned joining conditions must be satisfied not only in one plane, but perpendicular to the planes as well. Also the joining of the surfaces tangentially and continuously in curvature is also a requirement. This requirement can be only fulfilled by more and continuous iterations.



Fig. 31 Skull reconstruction and implant design

The output can be seen on the figure above. The implant joins to the extant part tangentially and in curvature continuously.

4.2 Creating a solid model of a pump with sections

The base of developing products is usually one of its previous versions. In case of a prior product it is not certain that its solid geometry is available. In such cases the previous 2D drawings can help to accelerate the planning process. Such a case is presented hereinafter.

The task is creating a solid model of the undermentioned pump housing with a quite complicated geometry.



Fig. 32 Volute chamber to be prepared

To form the interior (suction and pressure side) the following cross and radial sections are given.

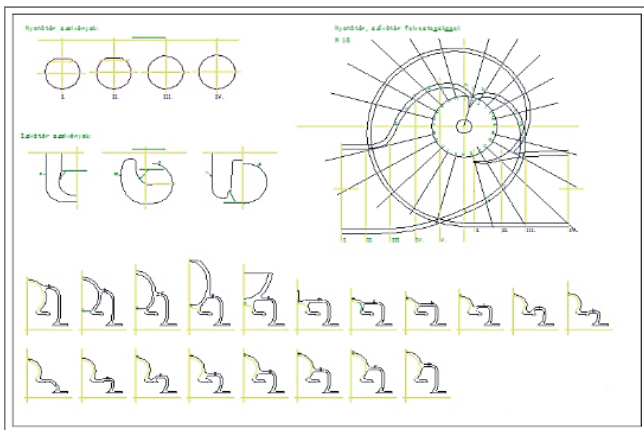


Fig. 33 Radial and cross sections

On the following figure a dimensioned section can be seen.

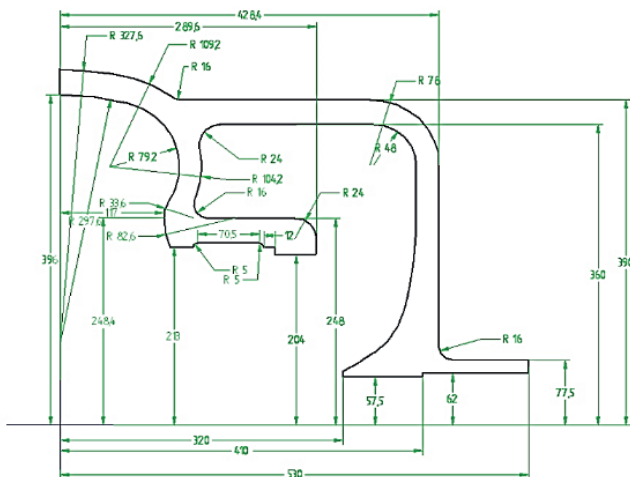


Fig. 34 An only section dimensioned

By ordering the sections properly we get the following result.

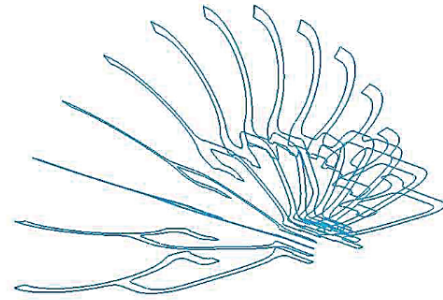


Fig. 35 Sections positioned

It is clear that due to the variation of the sizes of inlet and outlet the cuts and sections of them are also differ from each other. We can get the wanted geometry by result of a swept protrusion with multiple cross section. It is important to order the point to each other in the proper order because in case of a false order of the points the result will be also defective.

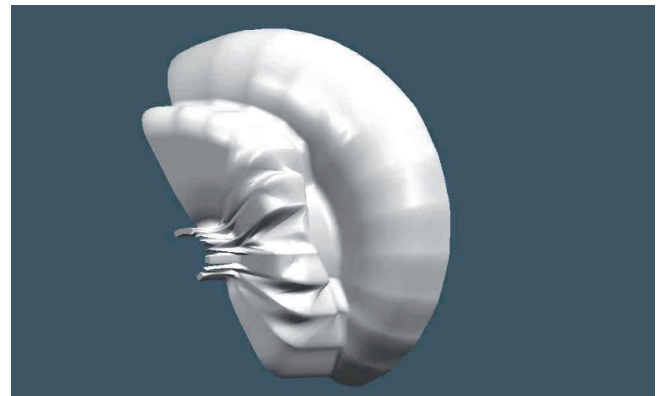


Fig. 36 Results of the false order of the points

Even in case of proper order of the points creating the solid geometry is not always an easy task because if there are excessive changes between the shape of sections the model cannot be defined in a mathematically exact way. On the following figure this geometry can be seen which was created by a swept protrusion with multiple cross sections.



Fig. 37 Results of the right ordered points

Creating connected surfaces, ribs and flanged hole features for bolt joints are much more simple task. The eventual geometry can be seen on the following figure.

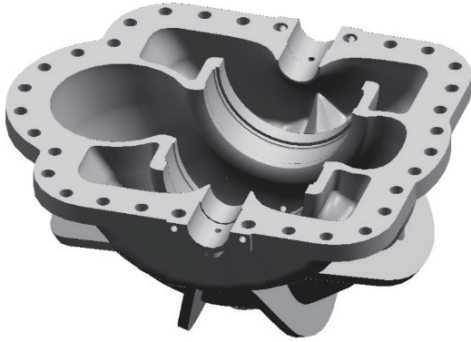


Fig. 38 3D CAD model of the pump housing

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