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RESEARCH ARTICLE

Use of Sections in the Engineering Practice

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Abstract
Thanks to 3D CAD modelling software the role of sections has been grown significantly. In this article we discuss the increasing role of sections. First we present some practical applications such as a section of a track and wheel and we also show how they can be used for mechanical calculations through an example of a shaft weakened with a keyway. The principle of additive manufacturing is also based on sections. Finally sections can be also used at optimizing parts, but in this paper we discuss only the case of shape optimizing.

Keywords
CAD modelling, section, cut, lofted protrusion, swept protrusion, revolved protrusion

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1 Introduction

Sections were originally generated from the already planned elements or geometries. They were used in cases when our task was defining the exact geometrical parameters of a given cut. Nowadays the role of sections increased significantly due to the appearance of CAD modelling software, what is more the use of them became indispensable (Győri and Ficzere, 2016). Even in the starting phase of 3D modelling we proceed from sections, but the role of them is also indispensable at additive manufacturing (3D printing). In many cases in numerical simulations to the exact finite element model the mesh is created by the help of sections. Nowadays on the base of finite element analysis with the data of sections used at CAD modelling it is possible to make shape optimisation as well.

2 Practical applications

2.1 Rail and wheel

2.1.1 Rail section

A well-known example of protrusion is modelling of rails, because the section of it is the same at any points in the whole length of the rail (Abramovics et al., 2015).

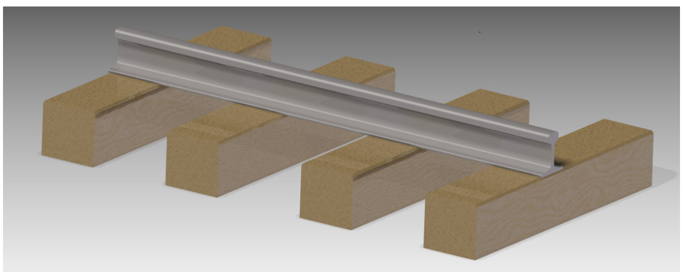

Fig. 1 Application of protrusion for rail tracks modelling

It is clear that the rail can be definied relatively simple along its length, because it can be defined by only one curve, but its cut has much more complicated geometry. A section of a first categorized rail, and its dimensions can be seen on the following figure.

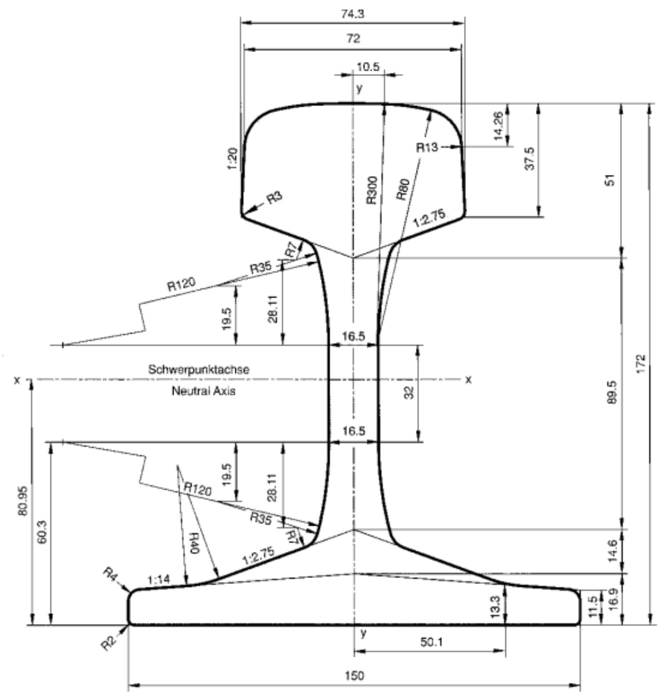

Fig. 2 Geometry of the section of rail track

2.1.2 Rail wheels on tracks

In case of straight section the rail can be modelled as a simple prismatic body, but in case of curved sections, it can be modelled as a swept protrusion with a constant section along a generating curve.

The railroad ties can be also modelled as a prismatic body. The wheels and the shaft can be created by revolved protrusion, but all parts shown in the following figure can be defined by a section and a path curve.

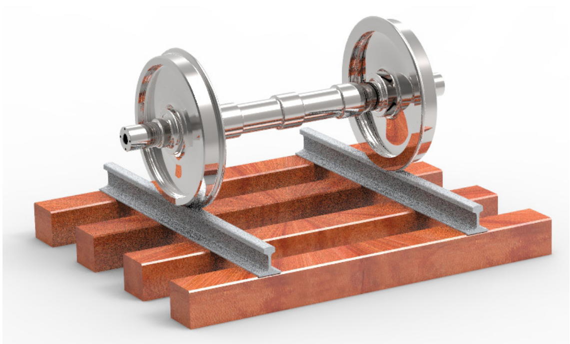

Fig. 3 Rail wheels on tracks

On the following figure the wheel and the shaft can be seen in a half-section. The outlines of the half-section can be obtained by revolving around the axis of simmetry.

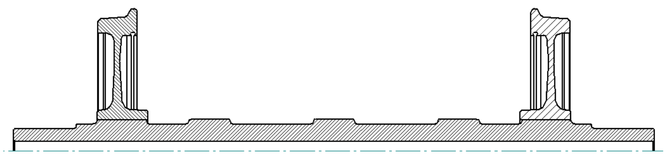

Fig. 4 Assembled rail wheels and shaft in a half-section view

2.2 Application of the sections for mechanical calculations

Possessing the solid geometry, also after the phase of shaping of planning, the components must be dimensioned. For dimensioning it is needed to know the material, the construction environment and the probable stresses. After prior calculations the critical stress places can be estimated where it is worth to investigate on. For the further exact mechanical dimensioning the main features of the cross section is needed. In case of simple geometries their calculation is relatively easy to calculate, but in case of complicated geometries it would require much more time and work. Using 3D CAD systems nowadays it is not a problem, the ultimate data of cuts and sections choosen optionally can be get by only one clicking.

As it can be seen on Fig. 5 for example the parameters of a section of a shaft weakened with a keyway can be get in such a simple way. These fundamental informations are the surface of the section, center of mass and the inertias.

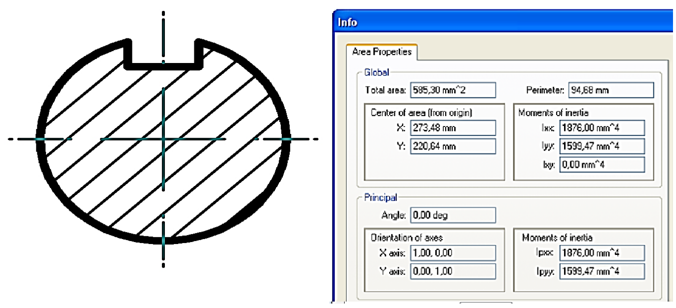

Fig. 5 Properties of a section

3 Additve manufacturing

Contrary to subtractive methods such as milling, drilling, turning etc at additve manufacturing the components are created with material addition. On the principle of Rapid Prototyping (RPT) which is nowadays called simply 3D printing, even the objects with the most complicated geometries are also can be produced. The main point of the process is that the solid geometry is created by building slim layers on each other. First the solid model must be sectioning to slim layers and after it these layers must be produced so that is could be joined properly to the other one under.

The realisation has a lot of well-known possibilities. These are for example LOM (Laminated Object Manufacturing), SLA (Stereolitography), SLS (Selective Laser Syntering), FDM

(Fused Deposition Modelling), Polyjet and 3D printing. The main principle of these are the same but they only differ in the way of realisation (Ficzere, 2014).

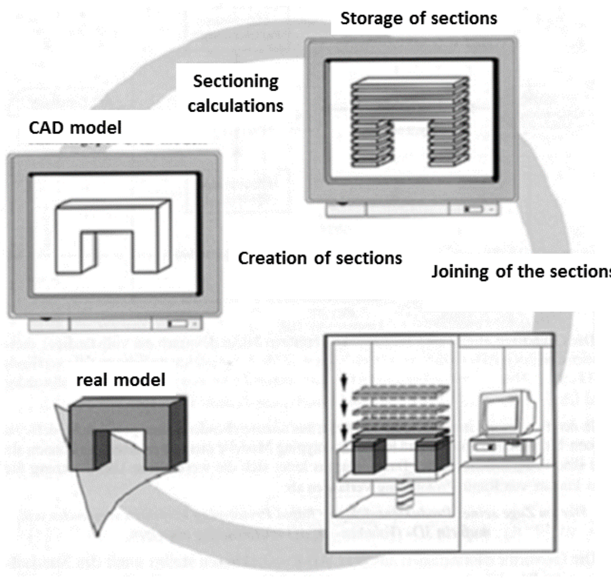

Fig. 6 Principle of additive manufacturing

The thicknesses of the layers also the distance of the sections have also a significant role in this cas. The more sections we take up, the better approximating we get as result.

As it is shown on Fig. 7 the higher values of curvature the more the difference from the originally geometry. But it is also clear, that it is worth to reduce the thicknesses of layers, also take up the sections closer to each other on behalf of the more precise result. It can be stated that the density of sections has an impact on the final geometry. It is important to note that in case of Rapid Prototyping the cost and the loadability depends on the number of taken sections (Ficzere, 2014; Ficzere et al., 2013).

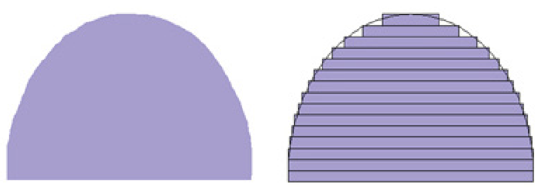

Fig. 7 Layers follows the geometry

4 Finite element modelling application of sections

The results of finite element analysis is influenced significantly by the finite element mesh. An inadequate mesh may cause serious mistake in our calculations (Fedorko et al., 2016). To get reliable results an appropriate mesh is needed, but it is usually quite complicated. There are some cases when the geometry to be analysed would be complicated to divide in a traditional way. Such a case is shown on the following figure.

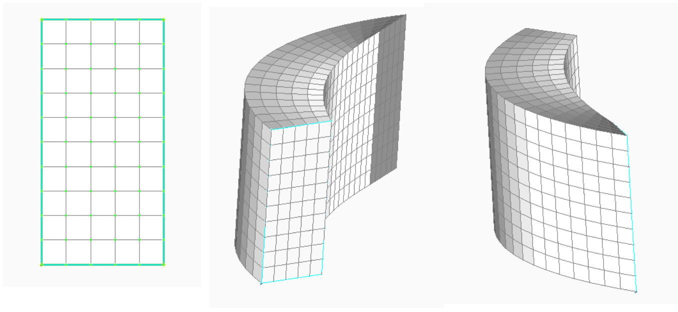

Fig. 8 Finite element mesh with the help of a section

In this case it is not practical to mesh the whole surface and after it the elements of the surface mesh to growth inside. A better mesh can be get if we make the meshing following the well visible revolved protrusion and extruded geometry. The first step is to divide the original surface by quadrilateral mesh, and these elements should be extruded together with an offset and revolved protrusion. The extrusion and revolved protrusion results volume elements. It is clear that the original section used during the modelling process can be used to create appropriate and uniform mesh.

5 Use of sections at optimization

Components should be optimized in particular purposes or conditions such as price, weight, stiffness and so on. Optimizing has many ways of which we discuss only the case of size optimizing. In this case we can only change some pre-defined sizes of our component but its shape and topology must not be changed. Such a case for example structures, sections of beams, thickness of sheet metals are sizes which can be changed – reduced or increased – to reach our purpose for example reducing its weight or improve its stiffness.

As it can be seen on Fig. 9 the prismatic rod with a constant section should be meshed with rod or beam elements. The number of the used elements will also decrease which reduces also the needed capacity and time of calculations.

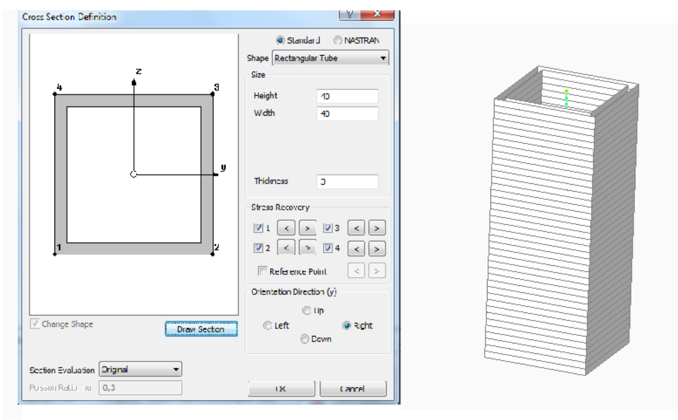

Fig. 9 Optimization parameters with usage of sections

An other important advantage of it is that the section (in this case 40x40x3 rectangular tube) can be defined only by a few parameters. These parameters can be given during the optimization process, as variables between some pre-defined limits. In order to get the optimal utilization of the material by holding the given strain or weight.

6 Summary

To sum up it can be stated that in engineering practice the role of setions became indispensable. Nowadays in contrary to the previous practice sections are not only generated from the already existing parts but they have to be used to create the 3D geometry of the elements. We proved our statement through some practical examples such as a rail wheel. We also shown how they can be used for mechanical calculations through an example of a shaft weakened with a keyway. The principle of additive manufacturing is also based on sections.

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