PREPARATION OF GEOMETRIC DATA FOR 3D PROTOTYPING

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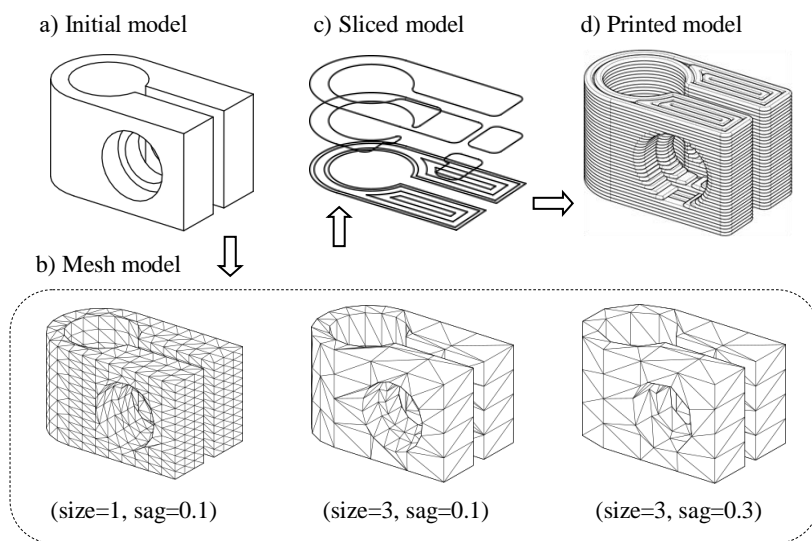*Scientific adviser - Pavlenko P., PhD, Associate Professor*

Despite the presence of high-tech CAD/CAM/CAE-systems, the problem of exchanging engineering data, primarily the structural elements of models, remains at this time not fully resolved. Both open data formats, such as STEP, IGES, etc., and polygonal STL formats, etc., do not solve the problem [1]. Of course, these problems increase as the complexity of product models grows, but they also exist when using 3D prototyping technologies [2].

In this report, the authors considered the influence of the parameters of the tessellated geometry on the accuracy of the resulting model, made on a 3D printer.

The STL and 3MF (aka 3D Manufacturing Format) formats are widely used for storing three-dimensional models of objects and transferring them in geometric data to equipment for rapid prototyping.

Three-dimensional geometry in leading 3D CAD systems is described by high-order surfaces, and during triangulation, the surface of the model is divided into small triangles - facets. Each facet is described by four datasets: the X, Y, Z coordinates of each of the three vertices, and a normal vector that describes the orientation of the facet, pointing outward of the model. For all layer-by-layer systems, it is necessary that the 3D model be "cut" in horizontal "slices" so that later it will be possible to reproduce its geometry in the form of a physical model layer by layer. Modern preprocessors made life easier for the calculator and began to work very efficiently with the STL format as an input geometry. The preprocessor creates a new mesh on STL geometry based on the mesh parameters specified by the calculator. First, a surface mesh is created, and then a volume mesh is created. This algorithm works reliably with a properly prepared STL file. Most modern CAD systems automatically create STL files from solid geometry. 3D solid data is converted to a polyhedral mesh of triangles and saved in an STL file. Models with too low or high resolution can cause problems in 3D printing and lead to unexpected results. So, for example, we created a low resolution STL file. Such 3D models will never provide us with the required surface quality, and, therefore, the print result will be unsatisfactory. Low resolution means that the triangles in the STL file are large and small. This will result in "pixel" or polygon printing. However, some people strive for this and create amazing 3D models in the LowPoly style. STL file with very high resolution. A file with this resolution will be "large" in size, which will not allow it to be opened at the stage of preparation for printing, and this extreme level of detail will not allow a 3D printer to print our model. However, if you need to have a highly detailed result, and especially with small dimensions, then you will need to work here. This task requires the selection of model approximation parameters taking into account the characteristics of the technological equipment (die diameter of the print head nozzle,

layer thickness, positioning accuracy). The figure shows a flowchart for evaluating the final accuracy of a physical prototype after printing. An experiment is planned, in which the parameters of the tessellation of the model size - the maximum allowable size of the side of the polygonal mesh, and sag - the allowable deviation of the mesh from the real model on curved sections are selected as controlled variables. In some design systems [3], the angular measure (the largest allowable angle between the tangent to the surface of the part and the plane approximating this part of the facet) is used as a parameter to control the accuracy of tessellation. This method allows you to equally accurately describe curved sections of different scales. However, for small elements, the density of grid nodes becomes much higher.

a) Initial model   c) Sliced model   d) Printed model

b) Mesh model

(size=1, sag=0.1)   (size=3, sag=0.1)   (size=3, sag=0.3)

The dimensions of the manufactured sample were used as a measured parameter. The objective function was defined as the standard deviation of the controlled dimensions from the mathematical model. The samples were grown on a Creality Ender 3X 3D Printer. Product material - PLA plastic (Monofilament).

As a result of the analysis of a series of experiments, dependencies were obtained that make it possible to determine the parameters of the grid model in order to obtain the optimal values of the accuracy of the printed model.

References:
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