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DESIGN AND VISUALIZATION OF CYLINDRICAL SHELLS

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Abstract. The paper proposes, on the basis of an analytical description, an option for designing the surface of a flexible shell structure of a cylindrical type, which in particular case, is a skirt. The construction of a three-dimensional model according to specified dimensional characteristics was carried out in the Maple environment based on the commands of the 4GL library. Construction of a shell structure in the form of a set of interconnected 3D graphic objects allows to combine curved surfaces, planes and spatial curves, and to view the structure from different points. Various structural elements, boundary lines and sections are rendered.

ПРОЕКТИРОВАНИЕ ОБОЛОЧЕК ЦИЛИНДРИЧЕСКОГО ТИПА И ИХ ВИЗУАЛИЗАЦИЯ

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Ключевые слова: проектирование оболочек, двумерная и трехмерная визуализация, пакет Maple, 3D графические объекты.
Аннотация. В работе предложен на основе аналитического описания вариант проектирования поверхности гибкой оболочечной конструкции цилиндрического типа, которой, в частности, является юбка. Построение трехмерной модели по заданным размерным признакам выполнено в среде Maple на основе команд библиотеки 4GL. Построение оболочечной конструкции в виде совокупности связанных между собой 3D графических объектов позволяет совмещать криволинейные поверхности, плоскости и пространственные кривые, выполнять обзор конструкции с различных точек. Прорисовываются различные элементы конструкции, граничные линии и разрезы.

Modern information methods are characterized by the use of digital technologies in all areas of production, which leads to a rapid increase in the number of different applications and software. In particular, visualization programs for various technical objects are widely used when modeling computer games, films, objects in architecture, construction, medicine, physics, when solving design problems, in design, in the advertising business, etc.

Construction of the volumetric-spatial form of the future product will allow the customer to inspect the designed product long before its physical execution, which allows both the customer and the contractor to decide on the choice of product, discuss possible design options, design features and show a number of

potential models and styles. Modern computer graphics capabilities make it possible to create digital twins for all product prototypes, inspect them, select the colors of various design parts and accessories, show objects in different lighting, and simulate the properties of materials.

Design of objects and visualization of their shape is performed in various software environments Maple, MathCad, Mathematica, MatLab, Embarcadero RAD Studio, 3ds Max, Maxima, etc. Visualization of objects is more convenient in the Maple, Embarcadero RAD Studio and 3ds Max environments since these packages have the ability to quickly create online applications for managing input parameters in the model in question. At the same time, in the Embarcadero RAD Studio and 3ds Max environments there are mismatches between the drawing of three-dimensional curves and surfaces, which requires adjustment and distortion of the real sizes of model elements.

In the paper the shell structures for which product prototypes are being developed are skirts, oriented towards a typical female figure. The purpose of the work is to design flexible shells based on an analytical description of their geometry using the Maple package, which in this case are skirts considered as part of clothing that protects the body from the aggressive influence of the external environment [2].

The work describes the construction of the skirt surface, boundary curves, waist element, articulation lines of structural elements, darts and cuts. The proposed model is described as a surface of rotation relative to the axis of symmetry of the woman's body [3]. The curve of the skirt's generatrix surface was determined based on non-contact projection of the customer's body shape onto a vertical plane after photographing a woman from the front. The generatrix, like a projection curve of a figure, is constructed from characteristic points, like a third-order polynomial regression curve. The work considered a miniskirt [4], for which the x and y coordinates of the projection of the figure's boundary on the frontal plane were determined in centimeters. Next, in Maple, based on the data array of characteristic points of the boundary curve, the regression equation for the generatrix was calculated. The regression for the generator is obtained in the form

$$y = 7{,}5 - 0{,}0099 \cdot x^2 - 0{,}00009 \cdot x^3. \qquad (1)$$

The relative discrepancy between the characteristic points and the regression dependence does not exceed 1%, which indicates good agreement between the correlation field and the regression equation.

The surface equation was constructed in a cylindrical coordinate system. For a miniskirt, the surface equation was obtained as:

$$\begin{cases} x = x; \\ y = r(x;t) \cdot \cos(t); \ 0 \le t \le 2\pi, \\ z = r(x;t) \cdot \sin(t); \end{cases} \qquad (2)$$

where the function $r(x;t)$ is given by the equation (1).

The limits of change in the vertical variable z are specified in a more complex form and are expressed through the Heaviside function

$$z = 3 \cdot Heaviside\left(-y + \frac{\pi}{2}\right) \cdot e^{a \cdot \left(y - \frac{\pi}{2}\right)} + Heaviside\left(y - \frac{\pi}{2}\right) \cdot e^{-a \cdot \left(y - \frac{\pi}{2}\right)} + \quad (3)$$

$$+ 3 \cdot Heaviside\left(-y + \pi\right) \cdot e^{a \cdot (y - \pi)} + Heaviside\left(y - \pi\right) \cdot e^{-a \cdot (y - \pi)} ...12{,}5.$$

This is due to the assignment of slits at the lower border of the skirt [5] (fig. 1).

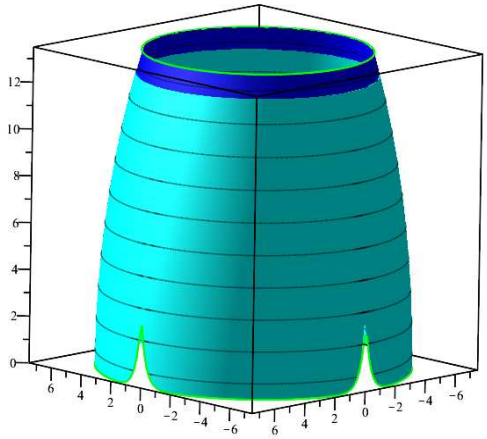

Fig. 1. Miniskirt, front view

Based on the Maple software package, an option for designing and visualizing a shell structure, which in a particular case is a skirt, is proposed. The following steps were implemented in the design process: construction of a generatrix of a cylindrical type surface, description of the surface of the product, construction of the boundaries of the product and the model as a whole. The proposed program allows you to inspect the product from different points and in different coordinate systems, select the colors of structural elements, add or exclude individual elements depending on the wishes of the customer. The proposed software product will make it possible to implement a wide range of shell structures in the form of skirts, taking into account their styles, features of the articulation of elements and cutting conditions.

The practical value of the work is that when designing shell structures, it becomes possible to solve problems of design automation, reducing material and labor costs when creating new models, significantly reducing the time for preparing projects, increasing the validity of newly created clothing designs, and developing a wide range of 3D doubles. Software tools allow you to transfer data about models on the Internet, receive information from the customer, quickly respond to their wishes and make the necessary additions to the proposed product model. The program can be used as an auxiliary tool in the production of textile products for designers to create new clothing models.

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