Marianna Vladimirovna Kiseleva[1]
Ludmila Olegovna Galtsova[2]
Varvara Vladimirovna Getmantseva[3]

Original Scientific Paper
UDC: 687.12.254.5.001.14

DEVELOPMENT OF THE METHOD TO CALCULATE THE SPATIAL FORM OF THE INTERNAL SURFACE OF SKIRT

***Abstract**: Article is devoted to the area research «visualization of the spatial form of a person's figure and clothes models» for the purpose of information bases development support of the parametrical module of 3D designing.*

The foundation of process of visualization of models of clothes the difficult mathematical apparatus describing the initial form (dummy) and the final form (product) lies. The article presents the description of development cycles of an original parametrical method of the task of an internal surface of a skirt base design of the (dummy), based on use of the mathematical equations of part-smooth surfaces.

In article are resulted it is unique the developed formulas of parameters calculation of the difficult spatial form, the equations of these forms surfaces are described. Conclusions of all formulas and the equations were logical and are made on the basis of detailed researches of subject domain.

Key words: three-dimensional model, the spatial form, figure surface.

RAZVOJ METODE PRORAČUNA FORME UNUTRAŠNJE POVRŠINE SUKNJE

1. INTRODUCTION

Modeling in 3D CAD is one of perspective directions of development of systems of the automated clothes designing. Introduction of three-dimensional technologies gives the chance to approach more creatively to process of designing of new clothes models. Designer works with spatial object he used to work with and has possibility to estimate and bring updating at a stage of creation of the sketch (three-dimensional model of appearance).

Development of a parametrical construction method of spatial models of a person's figure and a product is an important and insufficiently explored problem which is necessary for solving by development of program's modules 3D CAD. In existing three-dimensional systems of clothes designing the dummy and product surface is set by a discrete dot skeleton. At such sizing of a surface in system each time is made recalculation of set coordinates of the points belonging to a surface that demands working out of difficult mathematical ~~apparatus,~~ and consequently attraction of great volume of system resources.

[1] Department of Art modeling, designing and the production technology of garments, Moscow State University of Design and Technology, Moscow, Russia

Objectively there is a necessity of development of a sizing method of making a dummy's surface of a person's figure and a product which will provide possibility of editing of figure's parameters by changing dimensional signs and model parameters according to the set sketch.

Within the limits of the general research the private problem directed on development of a sizing method making of the spatial form of a dummy's internal surface of a base skirt design has been allocated. The basic difference of a dummy's internal surface of a base skirt from a dummy of a personal figure is the simplified algorithm of the sizing and construction of a spatial this object's surface. For construction of a skirt model, and especially volumetrical forms (i.e. with the large increases and strong backlog from a figure surface), it is not obligatory to consider all the features of a personal body surface.

2. SPATIAL FORM OF THE INTERNAL SURFACE OF SKIRT

The developed construction method of the compound spatial form of an internal skirt surface is based on the use of the mathematical equations of part-smooth surfaces that reduces number of the data entered and counted in automated system, allows editing a dummy quickly and easily.

The area of a surface of an article limited from above by section passing on the waist level, from below – section passing on the level of hips has been chosen for research.

At the first development stage of a mathematical method of a description of an internal surface of

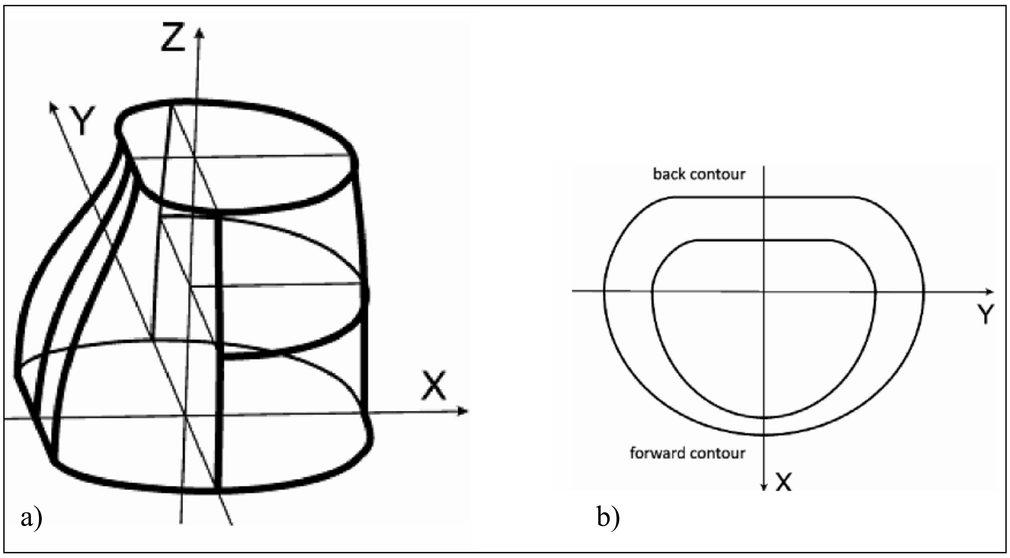

Figure 1 *Graphic model of a dummy's internal surface of a base skirt design: a) mutual positioning of the basic primitive things forming a surface; b) a mutual positioning of sections at level of a waist and hips.*

an article directions and an arrangement of axes of coordinates, a configuration and interposition of the basic primitive elements (curves) forming the spatial form of an internal surface of a base skirt design (*Figure 1a*, *1b*) had defined.

At the second stage of work the analysis of the geometrical form and basic parameters of the lines describing cross-section sections at level of a waist and hips had been carried out.

The allocated horizontal sections are divided into contours of a forward and back surface of a figure, according to an arrangement of a face-to-face plane (*Figure 2a*, *2b*).

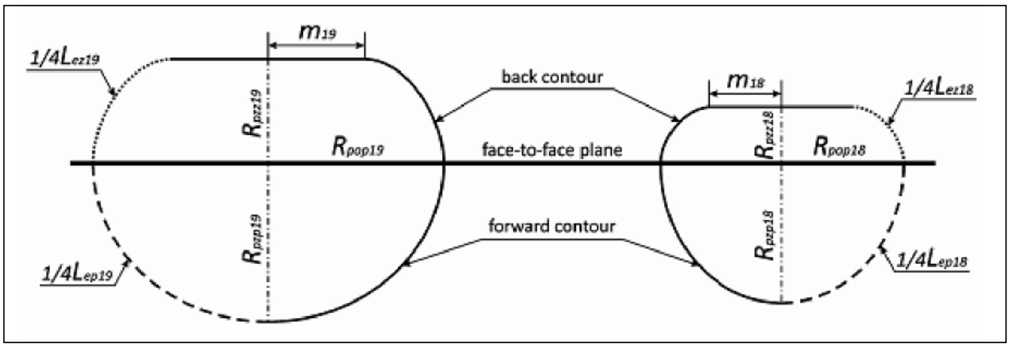

Figure 2 *Sections of the bottom basic surface of a figure: a) section at level of hips; b)section at waist level.*

Researches have shown that the presented sections are similar (*Figure 1b*), therefore for construction of these sections similar algorithms of calculation of parameters and sequence of graphic construction can be used.

On the basis of the analysis of the external form of a surface of female figures it is established that the forward contour of section on a waistline (*Figure 2b*) can be described by a part of a line of an ellipse. The following information is necessary for construction of a forward contour:

R_{pop18} – half of cross-section diameter waist (radius);

R_{pzp18} – radius frontback forward (a part of frontback diameter) waists;

L_{ep18} – length of a forward contour of an ellipse of waist section.

The back contour (*fig. 2b*) can be approximated a part of a straight line and a part of an ellipse with the displaced center concerning the center of the section. For construction of a back contour the following information is used:

R_{pop18} – half of cross-section diameter waist (radius);

R_{pzz18} – radius frontback back (a part of frontback diameter) waists;

L_{ez18} – length of a back contour of an ellipse of waist section;

m_{18} – straight line part of a back circuit of waist section.

Succession of the setting and the calculation of the parameters which were presented above, it is possible to describe the following algorithm presented in the generalized type in a *figure 3*. The algorithm consists of seven steps.

3. THE ALGORITHM DESCRIPTION

1. Input of the initial information.

The initial information for calculation of all necessary parameters are sized indications: T_1, T_{16} , T_{19}, T_{18}. [1].

2. Calculation of basic parameters.

As a result of numerous experiments empirical data on which basis are developed correlative dependences D_{popN} – diameter of cross N-th section from three leading sized indications (T_1,T_{16} ,T_{19}) have been received and is calculated $R_{popN} = \frac{1}{2} \cdot D_{popN}$. The received radiuses are accepted by basic elements of sections. On the basis of the initial data and the information received during research of the exterior form of a surface of a female figure, are calculated m_{18} and m_{19} (1).

$$m_{18} = m_{19} - \frac{0.35\Delta_{19-18}}{4} \qquad (1)$$

where m_{19}. is under the following formula:

$$m_{19} = \left(\frac{T_{19}}{4} - 1\right) \cdot 0,4 .$$

3. Calculation of sections' parameters.

The coefficients used in formulas (1), (2), (3) calculations are deduced on the basis of learning of allocation of a difference of lengths on lines of hips and a waist according to singularities of a constitution of female figures.

$$\frac{1}{4} L_{ez18} = \frac{1}{4} L_{ez19} - \frac{\Delta_{19-18}}{2} \cdot 0,425 \qquad (2)$$

where L_{ez19} is under the following formula:

$$\frac{1}{4} L_{ez19} = \left(\frac{T_{19}}{4} - 1\right) \cdot 0,6 .$$

$$\frac{1}{2} L_{ep18} = T_{18} - \frac{1}{2} L_{ez18} - 2m_{18} \qquad (3)$$

where T_{18} – value of 18th sized indications in accordance with State Standard Specification [1], sm

4. Check -up.

Important aspect of construction of sections is the exact sizing of a dimensional indications length: T_{18} ili T_{19}, accordingly. Therefore control of settlement length on lines of the sections which are passing at levels of a waist and hips (L_{18}, L_{19} is necessary. The given condition is written down as follows (4):

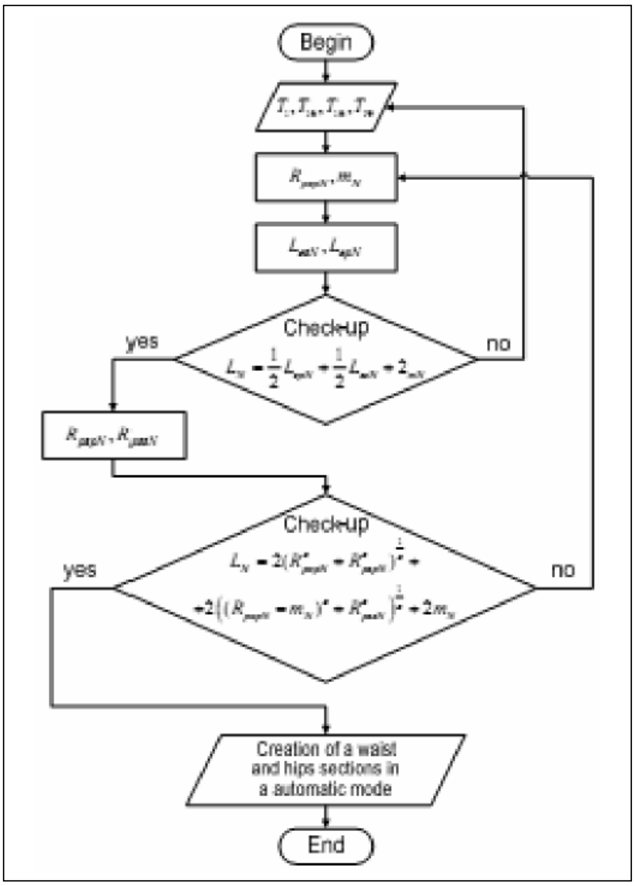

Figure 3 – *The flow chart of succession of the setting and calculation of sections parameters*

$$L_{18} = \frac{1}{2} L_{ep18} + \frac{1}{2} L_{ez18} + 2m_{18} = T_{18} \qquad (4)$$

5. Calculation of sections' radiuses.

Knowing length of an ellipse (L_{epN}) and one of its radiuses (R_{popN}), taking for a basis the formula for a finding of an ellipse length [2], the formula for definition of unknown section radius is expressed. Having put the known parameters into the found formula, we find necessary radiuses (5), (6).

$$R_{pzp18} = \left[\left(\frac{L_{ep18}}{4}\right)^x - R^x_{pop18}\right]^{\frac{1}{x}} \qquad (5)$$

$$R_{pzz18} = \left[\left(\frac{L_{ez18}}{4}\right)^x - \left(R_{pop18} - m_{18}\right)^x\right]^{\frac{1}{x}} \qquad (6)$$

6. Check-up.

For construction of the set length sections it is necessary to check up the possibility of receiving desirable result on the basis of the calculated radiuses. Therefore check of settlement length of projected section is carried out under the following formula (7):

$$L_{18} = 2\cdot\left(R_{pop18}^{x} + R_{pzp18}^{x}\right)^{\frac{1}{x}} + 2\cdot\left(\left(R_{pop18} - m_{18}\right)^{x} + R_{pzz18}^{x}\right)^{\frac{1}{x}} + 2\cdot m_{18} \quad (7)$$

7. A graphic representation conclusion.

The received formulas of key parameters calculation applied to the construction of a dummy's sections of an internal surface of a base skirt design, are information support of the program module by means of which calculation (on the algorithm presented on *Figure 3*) and construction of sections in an automatic mode on any size-growth is made.

At such calculation the sections are settled down correctly from each other in horizontal planes. The relative error between the sections constructed on the basis of established dependences, and size of an initial dimensional indications makes 0.01÷0.03 %.

At the third stage for construction of the bottom basic surface of a personal figure, have been studied, and vertical contours of various types of female figures are mathematically described (*Figure 4a*, *4b*).

Based on a configuration of the curves describing forward, lateral and back contours of the spatial form of an internal surface of a base skirt design, the surface is set by following equations (8), (9), (10), (11):

For the first part (*Figure 4a*):

$$\frac{x^2}{\left[\frac{R_{pzp19} - R_{pzp18}}{2}\left(1 + \cos\frac{\pi\left(Z - h_g\right)}{h_p - h_g}\right) + R_{pzp18}\right]^2} + \frac{y^2}{\left[\frac{2{,}48\cdot\left(R_{pop19} - R_{pop18}\right)}{h_{bok}^3}\cdot Z^3 \; \frac{1{,}48\left(R_{pop19} - R_{pop18}\right)}{h_{bok}^2}\cdot Z^2 - R_{pop19}\right]^2} = 1 \quad (8)$$

where h_p – height from hips line to a waistline in front, sm; h_g – heights of an acting point of a stomach, sm; h_{bok} – height from hips line to a waistline sideways, sm.

$x \in \left[0; +R_{pop19}\right]$;
$y \in \left(-R_{pop19}; +R_{pop19}\right)$;
$z \in \left[h_g; h_{tb}\right]$.

For the second part (*Figure 4a*):

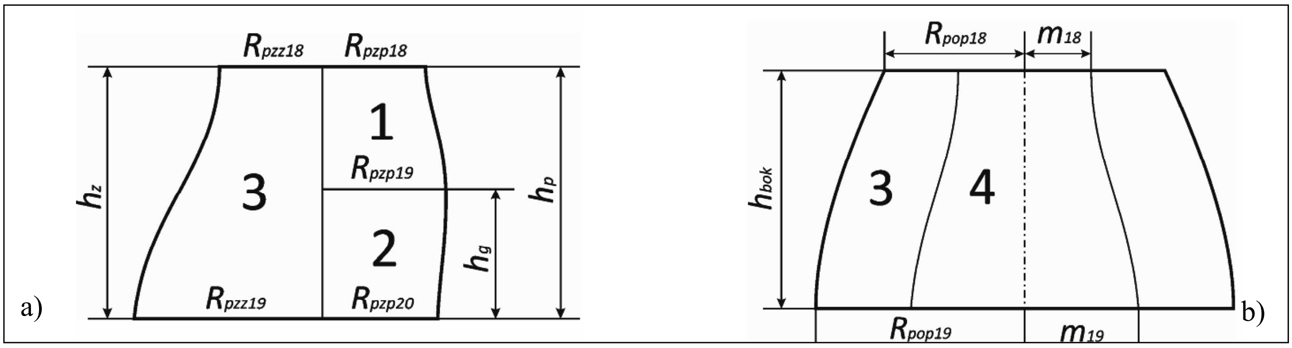

Figure 4. *Parameters of a dummy's internal surface of a base skirt design: a) parameters and parts of the bottom basic surface (side view); b) parameters and parts of the bottom basic surface (back view).*

By results of research the bottom basic surface is divided into 4 parts (*Figure 4a*, *4b*). The first and second parts belong to a forward contour of the bottom basic surface, and the third and the fourth – to a back contour. The first part is limited by the sections which are passing at level of a waist and the acting point of a stomach, the second – at level of an acting point of a stomach and hips, the third and fourth sites limited to sections at level of a waist and hips, and vertically division passes according to values m_{18} and m_{19}.

$$\frac{x^2}{\left[\frac{R_{pzp19} - R_{pzp20}}{2}\cdot\left(1 + \cos\frac{Z\cdot\pi}{h_g}\right) + R_{pzp20}\right]^2} + \frac{y^2}{\left[\frac{2{,}48\cdot\left(R_{pop19} - R_{pop18}\right)}{h_{bok}^3}\cdot Z^3 - \frac{1{,}48\cdot\left(R_{pop19} - R_{pop18}\right)}{h_{bok}^2}\cdot Z^2 - R_{pop19}\right]^2} = 1 \quad (9)$$

where

$x \in [0; R_{pzp19}]$;

$y \in [-R_{pop19}; +R_{pop19}]$;

$z \in [0; h_{tb}]$.

For the third part (Figure 4a, 4b):

$$\frac{x^2}{\left[\frac{R_{pzz19}-R_{pzz18}}{2}\cdot\left(1+\cos\frac{2\cdot\pi}{h_z}\right)+R_{pz18}\right]^2}+$$

$$+\frac{\left[y\pm\left(m_{18}-\frac{m_{19}-m_{18}}{h_z}(Z-h_z)\right)\right]^2}{\left[\frac{2{,}48\cdot(R_{pop19}-R_{pop18})}{h_{bok}^3}\cdot Z^2-\frac{1{,}48(R_{pop19}-R_{pop18})}{h_{bok}^2}\cdot Z^2-R_{pop19}\right]^2}=1 \quad (10)$$

where h_p – height from hips line to a waistline in front, sm;

$x \in [-R_{pzz19}; 0]$;

$y \in [\pm m_{18}; \pm R_{pop19}]$;

$z \in [0; h_z]$.

For the fourth part (Figure 4b):

$$X=\frac{m_{19}-m_{18}}{2}\cdot\left(\cos\frac{Z\cdot\pi}{h_z}+1\right)+m_{18} \quad (11)$$

where $x \in [-R_{pzp19}; 0]$;

$y \in [-f(z); +f(z)]$;

$z \in [0; h_z]$.

4. CONCLUSION

In summary, the presented parametrical method of sizing the spatial objects, based on application of the mathematical equations of part-smooth surfaces, allows to reduce number of the entered and settlement data, receiving realistic three-dimensional model of a dummy of an internal surface of a base skirt design on any type of a figure and the size-growth, constructed on the basis of the task of three basic dimensional indications. The parametrical sizing of a surface provides possibility of reception of the information on any point of a surface. Such sizing of a three-dimensional surface doesn't demand the large expenses of system resources for calculation of parameters of a surface and its graphic display. Implementation of the developed method of the sizing a surface of object will allow to reduce considerably the expenses of time for working out a model as a whole.

REFERENCES

[1] Book: OJSC «CSRICI» (2003), *SSS 17552-72, Typical figures of women. Dimensional signs for clothes designing,* TPM

[2] Book: Vygodsky M (2010), *Directory on higher mathematics,* TPM