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DESIGN FEATURES CLOSED CONTOURS FIRST ORDER SMOOTHNESS IN BN-CALCULATION

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The paper presents the research methods of determining the tangent in design of closed contours of the first-order smoothness in BN-calculation for the simulation of closed rings on the surface of the tank for the storage of oil and oil products, taking into account the imperfections of geometric shapes.

Key words: a closed contour, contour by arc, tangent, BN-calculation, point equation, curvature of the curve.

Formulation of the problem. This article is a continuation of the work of the authors on the study of methods for the analytical determination of non-regular surfaces of technical forms in BN-calculus using the example of determining the actual surface of a tank for storing oil and oil products, taking into account imperfections of geometric shape. To construct the necessary surface of a tank of irregular shape, it is necessary to have algorithms for constructing closed and non-closed contours of first order of smoothness. Moreover, closed circuits are guides, and non-closed ones are generatrices of the surface of the reservoir. However, during the research it was found that the construction of a convex contour of the first order of smoothness composed of arcs of Bézier curves of the third order gives curvature far from the circle. Thus, instead of obtaining an accurate description of the given imperfections of the geometric shape, as a result new unplanned distortions are obtained which reduce the reliability of the geometric model and, as a result, the accuracy of calculations for the strength and stability of the reservoir. This problem was solved by the authors by choosing the lengths of the tangents at the points of joining the contour.

Analysis of recent research and publications. As noted earlier, in [1], a large number of papers were devoted to studies in the construction of convex contours, in which cases of constructing contours with a smoothness order were considered and the higher the first, but for simulating an unconstrained surface by the moving simplex method [2], it is necessary Their description is within the BN-calculus [3].

Geometric bases for constructing one-dimensional and two-dimensional contours in BN-calculus were developed in [4]. Where in the framework of BN-calculus Professor Balyuba were proposed algorithms for modeling any circuits of the first order of smoothness, including closed ones, using the 3rd-order Bezier curve as arcs. But the use of these algorithms to model directly the surface of storage tanks for oil and oil products, led to the need for further research and improvement of existing algorithms proposed in [4].

Formulation of the purpose of the article. Improve existing algorithms for modeling closed circuits of the first order of smoothness, taking into account the necessary curvature of the resulting composite closed curve.

Основная часть. Suppose that there are k points: $A_1, A_2, ..., A_k$, through which a closed loop should be drawn. This means that the last -th arc of the contour will be determined by points A_k and A_1. Such closure of the contour should be organized in accordance with the requirements and based on algorithms that were considered in [1]. Also, when constructing a closed contour, it should be taken into account that the point A_1 will coincide with the point A_{k+1} And the tangent, which provides the first order of smoothness of the closed contour, will also be common. In accordance with the geometrical scheme for constructing the contour (fig. 1), to determine the tangents and construct the arc of the contour in the -m section, two more points A_{i+1} and A_{i+2}. Taking this into account when constructing a closed contour, it should be assumed that $A_2 \equiv A_{k+2}$ and $A_3 \equiv A_{k+3}$. This is necessary to determine the tangent arcs of the contour, for which condition: $B_1 \equiv B_{k+1}$ and $C_1 \equiv C_{k+1}$.

Given all of the above, we get the following algorithm for constructing a closed contour.

1. Determine the length of a segment $A_i A_{i+1}$:

$$|A_i A_{i+1}| = \sqrt{\sum \ A_i - A_{i+1} \ ^2}, i = 1, 2, ..., k+1.$$

$|A_{i+1} A_{i+2}|$ we determine from this point by a shift by one. We accept $A_1 \equiv A_{k+1}$ and $A_2 \equiv A_{k+2}$.

2. Determine the length of a segment $A_i A_{i+2}$:

$$|A_i A_{i+2}| = \sqrt{\sum \ A_i - A_{i+2} \ ^2}, i = 1, 2, ..., k+1.$$

We accept $A_1 \equiv A_{k+1}$, $A_2 \equiv A_{k+2}$ and $A_3 \equiv A_{k+3}$.

3. Determine the points B_{i+1}, C_{i+1} forming the form of the contour arc:

$$B_{i+1} = (A_{i+2} - A_i)\frac{|A_{i+1}A_{i+2}|}{2|A_iA_{i+2}|} + A_{i+1}, i = 1,2,...,k+1.$$

$$C_{i+1} = (A_i - A_{i+2})\frac{|A_iA_{i+1}|}{2|A_iA_{i+2}|} + A_{i+1}, i = 1,2,...,k+1.$$

We accept $B_1 \equiv B_{k+1};\ B_2 \equiv B_{k+2};\ C_1 \equiv C_{k+1};\ C_2 \equiv C_{k+2}$.

4. We form an arc of a contour of double curvature of the third order:

$$M_i = A_i\bar{t}^3 + 3B_i\bar{t}^2 t + 3C_{i+1}\bar{t}t^2 + A_{i+1}t^3, \text{ где } i = 2,...,k+1.$$

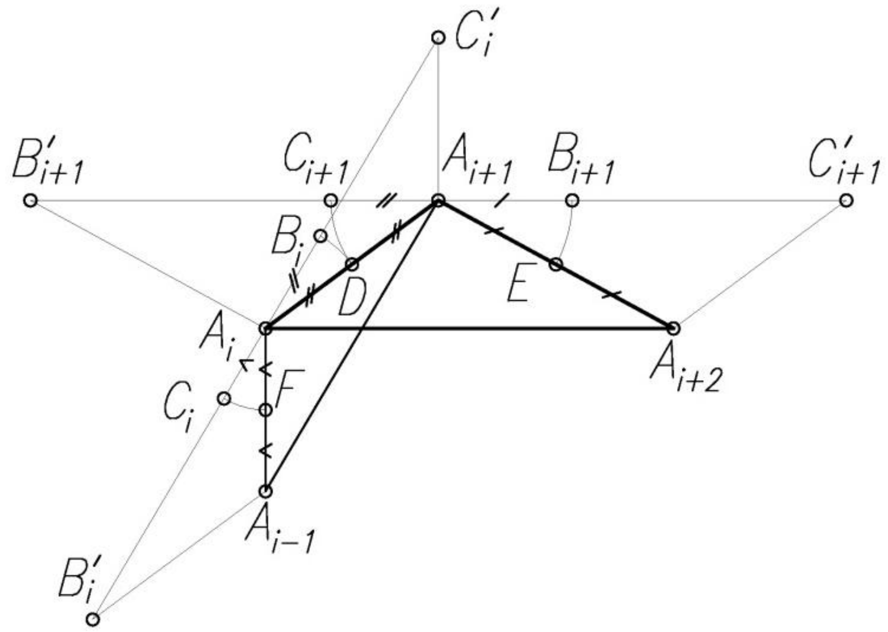


Fig. 1. Selection of tangents at internal points of the contour

In the proposed algorithm, the definition of points B_{i+1} и C_{i+1}, which, in turn, specify the form of the contour arc, belong to the straight line $B'_{i+1}C'_{i+1}$ and divide the corresponding segments $A_{i+1}A_{i+2}$ and A_iA_{i+1} in half. However, in order to obtain a translation that is close, by its characteristics, to a circle, the points B_{i+1} and C_{i+1}, Defining the form of the arc of the bypass, must belong to the straight line $B'_{i+1}C'_{i+1}$, but the sum of the lengths of the tangents for each section of the bypass should be less than the chord length of the corresponding section. We have experimentally established that the closed contour has the closest curvature to the circle when the lengths of the tangents at the points of joining the contour:

$$|A_{i+1}B_{i+1}| = \frac{|A_{i+1}A_{i+2}|}{\pi}; \qquad |A_{i+1}C_{i+1}| = \frac{|A_iA_{i+1}|}{\pi}. \tag{1}$$

Let us determine from this condition the required points B_{i+1} and C_{i+1}:

$$\frac{|A_{i+1}B_{i+1}|}{|A_{i+1}C'_{i+1}|}=\frac{|A_{i+1}A_{i+2}|}{\pi|A_iA_{i+2}|}=\frac{A_{i+1}B_{i+1}}{A_{i+1}C'_{i+1}}\Rightarrow\frac{B_{i+1}-A_{i+1}}{C'_{i+1}-A_{i+1}}=\frac{|A_{i+1}A_{i+2}|}{\pi|A_iA_{i+2}|}\Rightarrow$$

$$\Rightarrow B_{i+1}=(C'_{i+1}-A_{i+1})\frac{|A_{i+1}A_{i+2}|}{\pi|A_iA_{i+2}|}+A_{i+1}.$$

Further, taking (1) into account, we obtain:

$$B_{i+1}=(A_{i+2}-A_i)\frac{|A_{i+1}A_{i+2}|}{\pi|A_iA_{i+2}|}+A_{i+1}. \qquad (2)$$

Similarly we define C_{i+1}:

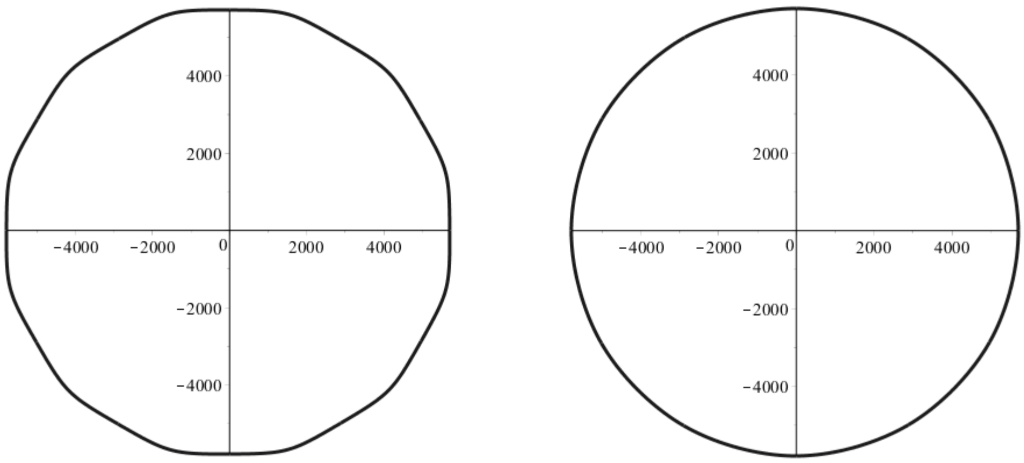
$$C_{i+1}=(A_i-A_{i+2})\frac{|A_iA_{i+1}|}{\pi|A_iA_{i+2}|}+A_{i+1}. \qquad (3)$$

This approach to the selection of tangents can be generalized as follows:

$$\begin{aligned}B_{i+1}&=(A_{i+2}-A_i)\frac{|A_{i+1}A_{i+2}|}{n|A_iA_{i+2}|}+A_{i+1};\\C_{i+1}&=(A_i-A_{i+2})\frac{|A_iA_{i+1}|}{n|A_iA_{i+2}|}+A_{i+1},\end{aligned} \qquad (4)$$

where $n\geq 2$, in accordance with the condition set forth in [1].

As an example, fig. 2 shows one of the guide rings of the surface of the tank, taking into account the imperfections of the geometric shape. Accordingly, in fig. 2, a, the result of simulating a closed contour according to the algorithm proposed in [4] is presented, and in fig. 2, b is the result of the work of the improved algorithm, for which the tangents at the points of joining the arcs of the contour are determined by the relations (2) and (3).



a) *b)*

Fig. 2. Results of constructing a closed contour
First order of smoothness

Conclusions. The influence of the lengths of the tangents on the shape and curvature of a closed contour of the first order of smoothness is investigated. On the basis of these studies, a geometric model of the surface of a reservoir for storage of oil and petroleum products with a volume of 1 m3 was obtained, taking into account imperfections in the geometric shape, and the finite-element stress-strain state calculation was performed, which makes it possible to evaluate with great certainty its technical condition and take necessary and economical Justified measures to maintain its efficiency.

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