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Selection of rational geometrical parameters of profile of moment transmitted connections

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Abstract
In the article, the problem by determination of rational geometrical parameters of profile section on the basis of Reuleaux triangle is considered. The characteristic of section form changeability depending on various ratios of section geometrical parameters is described. The solution of search of rational parameters K, at which, it is possible to obtain this section from the workpiece of circular section, is provided.
Key words: POLAR MOMENT OF INERTIA, PROFILE CONNECTION, NORMAL STRESS, TANGENTIAL STRESS, STRENGTH

The use of profiling shafts instead of castellated and spline ones in the industry (machine and automobile construction and instrument making) is perspective in terms of sufficient reliability ensuring of heavy loaded connections [1, 2, 3, 4]. The shearing stresses, which depend inversely on this section polar moment, appear during torque transmission in profile section on the basis of Reuleaux triangle. In this regard, there appears a task of search of polar moments rational values, at which the tangential stresses could be the smallest; thus, it is necessary to consider that a shaft of this profile is made of workpiece of circular section.

Let us consider the sections of profile moment transmitted section (Fig. 1).

For this section, the calculation of the polar moment was conducted [5]:

$$I_\rho = R^4(0.08212820665K^4 + 0.3961779179K^3 + 0.6141847019K^2 + \\ + 0.3961779178K + 0.08212820665)$$

where R – radius of circumscribed circles from the corners of the central triangle;

K – the parameter considering a ratio of radiuses R and r;

r – radius of circumscribed circles from the corners of small triangles.

$$K = \frac{r}{R} \qquad (1)$$

Using the obtained dependence, it becomes possible to determine to high precision the normal and tangential stress arising in profile connection during torque transmission. These dependences can be used during the automated strength calculation of connection according to the 3rd theory of strength. This will allow reducing of time for design-engineering preparation for production of the items containing the connections on the basis of Reuleaux triangle in their design [5].

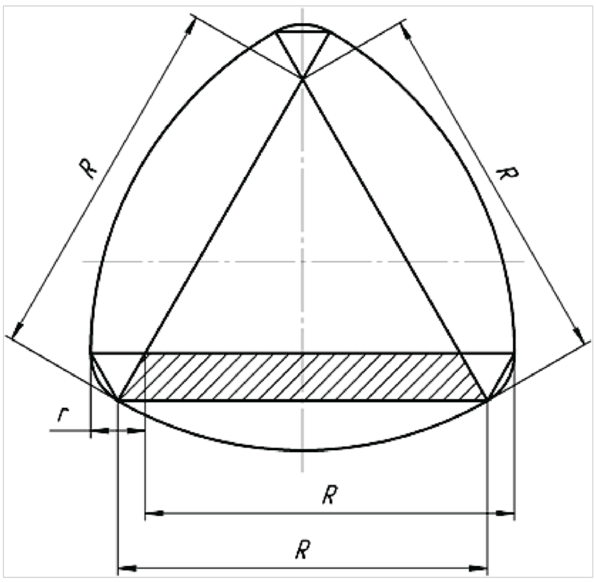

Figure 1. The section of moment transmitted shaft

Therefore, it is necessary to solve a problem of rational ratios (expressed by the parameter K) of radiuses of this section inscribed in a circle. This parameter influences the polar moment directly.

If $r \to 0$; K=0, the profile section is changed into Reuleaux triangle [6].

This type of profile section differs by the ease of production [7]; however, it has stress risers that reduce its operational properties significantly in comparison with the profile presented in Fig. 1.

If R≈r, K≈1, the profile section is changed into a circle.

$$R = a + r \quad (2)$$

where a – side of the central triangle.

$$r = \frac{a \cdot K}{1-K}, \; when \, K \neq 1 \quad (3)$$

and R similarly:

$$R = \frac{a}{1-K}, \quad when \, K \neq 1$$

Let us describe round section a circle with a diameter D with the center in the gravity center of the central triangle, so we obtain:

$$D = 2\left(\frac{\sqrt{3}}{3}(R-r) + r\right) = \frac{2\sqrt{3}}{3}R + 2 \cdot r(1 - \frac{\sqrt{3}}{3})$$

$$D \approx 1{,}155R + 0{,}845r$$

We can express r and R:

$$R = \frac{D - 0{,}845r}{1{,}155}$$

$$r = \frac{D - 1{,}155R}{0{,}845}$$

Let us substitute these expressions into parameter K:

$$K = 1{,}3679 \cdot (\frac{D - 1{,}155R}{D - 0{,}845r})$$

From the condition that $K \geq 0$, we obtain the system of linear inequalities:

$$\begin{cases} R \leq 0{,}866D \\ r < 1{,}19D \end{cases}$$

Let us substitute the formula (2) in this system:

$$\begin{cases} r \leq 0{,}866D - a \\ r < 1{,}19D \end{cases}$$

Let us set the boundary conditions:

a >0;

$r \leq D/2$(imaginary circle),

then the system will be transformed to the following expressions:

$$\begin{cases} r \leq 0{,}866D - a \\ 0 < r \leq 0{,}5D \end{cases}$$

The system will have solutions if

$$0{,}366D \leq a < 0{,}866D$$

Let us solve the system concerning r, we express a from formula (3):

$$a = r(\frac{1-K}{K})$$

Let us substitute this expression in the system of linear inequalities and we will solve it:

$$0{,}366D < \frac{0{,}5D(1-K)}{K} < 0{,}866D$$

$$0{,}366 < K \leq 0{,}577$$

Now, we solve the system concerning R:

$$\begin{cases} 0{,}366D \leq a < 0{,}866D \\ 0 < r \leq 0{,}5D \\ a + r = R \end{cases}$$

$$0{,}366D \leq R < 1{,}366D$$

Let us express a from (4):

$$a = R(1-K)$$

We substitute this expression into inequality and solve it:

$$\begin{cases} 0{,}366D < 1{,}366D(1-K) < 1{,}366D \\ 0{,}366D < 0{,}366D(1-K) < 1{,}366D \end{cases}$$

$$0{,}366 \leq K < 0{,}73$$

Finally, we obtain the limits of parameter K, for which, it is possible to inscribe section in a circle with a diameter D:

$$0{,}366 < K \leq 0{,}577$$

If it appears that parameter K<0,366, the parametrical section becomes less insignificantly than circumscribed circle.

If the parameter K>0,577, the border of circumscribed circle on a curve of small radius r is observed (Fig. 3).

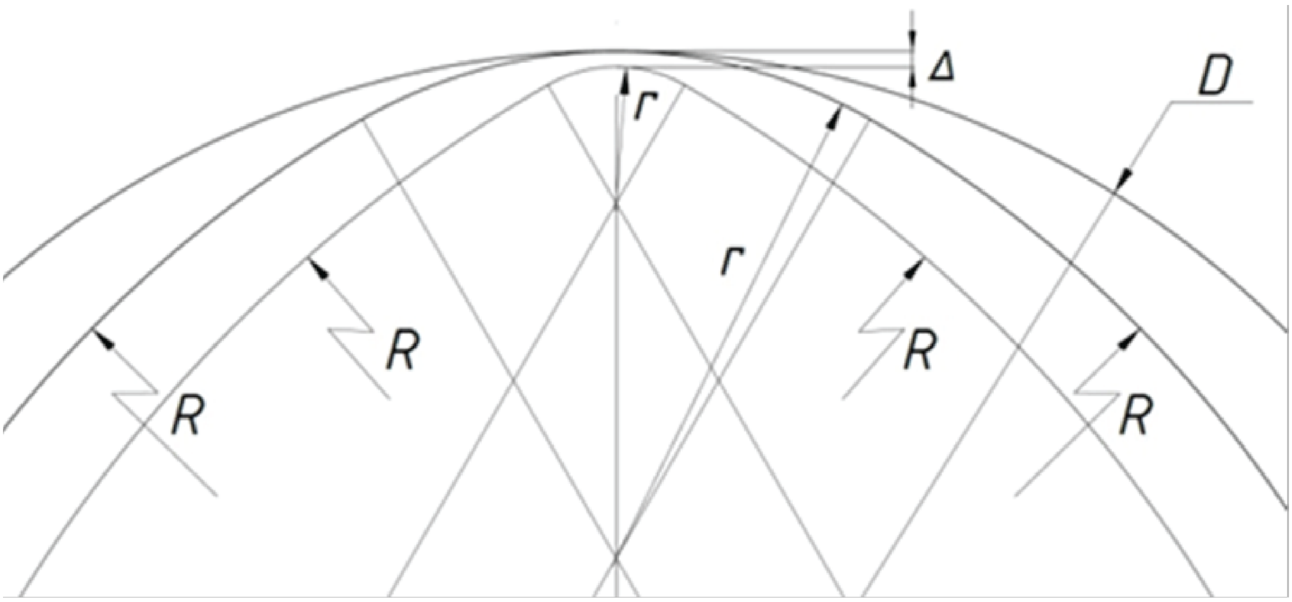

Figure 2. Violation, at which the parametrical section becomes less insignificantly than circumscribed circle

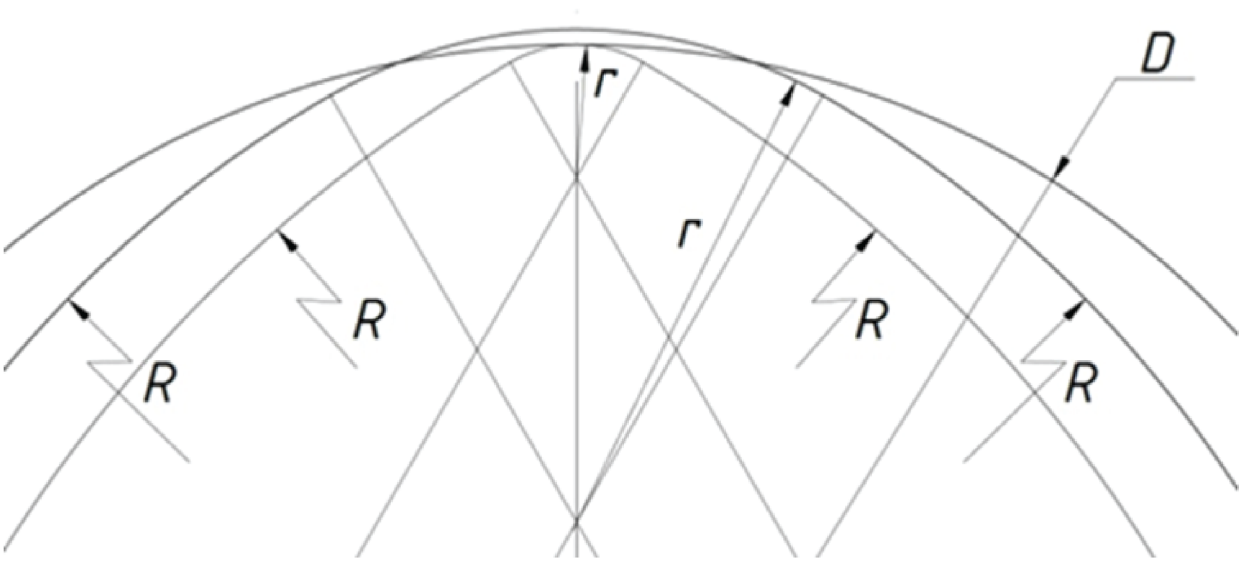

Figure 3. Violation of border of circumscribed circle on a curve of small radius r

The obtained interval of parameter K will allow reducing of further time of parametrical section optimum form selection.

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Factors determining the intensity of loading of long operated gas pipelines under complex mining and geological conditions

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