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Contact Ratio in Involute-Pin Meshing

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Abstract: *Two versions of chainless (rack) mechanism of a shearer loader's haulage system are discussed with usage of pin meshing. The geometry of the meshing is examined and the contact ratio is set. Conclusions are made and recommendations are given to producers of shearer loader.*

Key words*: shearer loader, haulage system, pin meshing, contact ratio.*

One of the main parts of modern underground coal long wall complexes is the sharer loader [1], [2], [3]. The haulage system ensures its movement along the coalface. It may be: chain type (out side or built in) or chainless (rack) type. The last one is used mainly with new sharer loaders [3], [4]. The chainless haulage system resembles a rugged support (with rack), traveling mechanism and hold system.

The rugged support is fixed to the length of the face conveyor and consists of separate hinged elements.The traveling mechanism of built- in haulage systems is located in the corpus of the shearer loader and consists of motor and gear train with driving element (gear wheel) on its output shaft which rolls on the rack. Besides the traveling mechanism with the driving element are moving together with the shearer loader while the support (rack) is fixed. The hold system consists of various breaking devices which hold-up the shearer loader in case of traveling mechanism switches-off or failure.

The purpose of this work is to investigate the geometry of the meshing of different versions of rack shearer loader's haulage system.

Fig. 1 shows the meshing of pin wheel with rack. If the wheel is rolled on the right, the center of the pin describes an epicycloid α, if it is on the left side – epicycloid β. These epicycloids will be the profiles of the teeth of the rack. Taking into account the fact that the pins of the wheel have a radius r_p, the profile of the rack teeth will be determined by curves α_1 and β_1, equidistant to α and β.

In the meshing of the center of the pins, the line of action will be the pitch circle with a radius r of the wheel. In meshing of pins with radius r_p the line of action is determined by the following considerations:

At the starting point the circle r touches the pitch (reference) line of the rack $a-a$ at point P. This will be the beginning of the line of action. When rolling the circle r on the pitch line $a-a$ after a certain time the point of contact will be at point P'. When the radius of pin is $r_p \neq 0$ the contact will be implemented in point M. The conjugated profiles of the teeth of the wheel and the rack must have a common normal at the point of contact. The chord line PP' is a normal to a point lying on the epicycloid β_1. The radius MP' is a normal to a point lying on the circle with radius r_p. Lines PP' and MP' match, therefore, through point M passes the common normal for the both profiles.

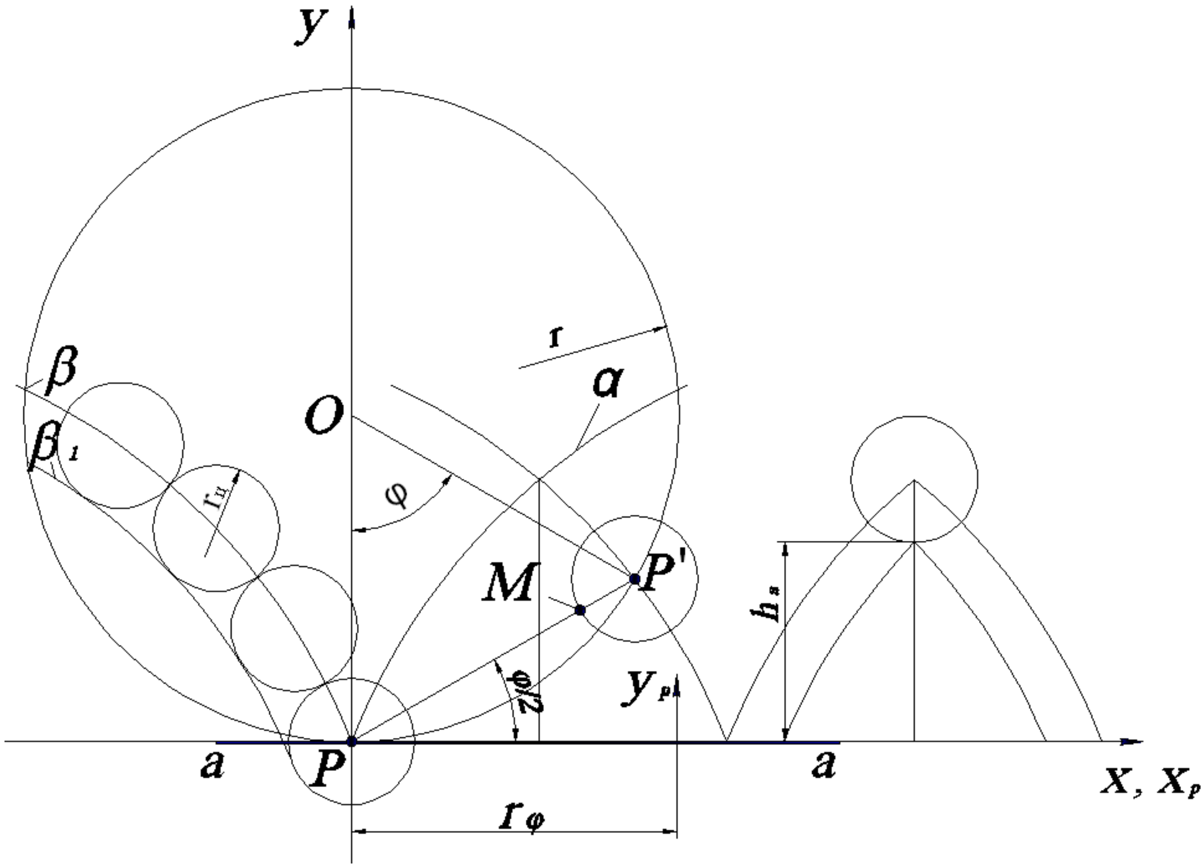

Fig. 1. Cycloidal-pin rack meshing

Section PP' can be expressed through the central angle φ, on which is the pitch circle has rolled when it was on $a-a$, until the contacting point P', $PP' = 2*r*\sin\frac{\varphi}{2}$. Then in the stationary coordinate system x, y, the meshing equation is [7]

$$x = \left(2*r*\sin\frac{\varphi}{2} - r_p\right)*\cos\frac{\varphi}{2}, \quad (1)$$

$$y = \left(2*r*\sin\frac{\varphi}{2} - r_p\right)*\sin\frac{\varphi}{2}. \quad (2)$$

The equation of the profile of the rack teeth in a coordinate system x_r, y_r, connected with the rack is [7]

$$\begin{cases} x = \left(2 * r * \sin\dfrac{\varphi}{2} - r_p\right) * \cos\dfrac{\varphi}{2} - r * \varphi, \\ y = \left(2 * r * \sin\dfrac{\varphi}{2} - r_p\right) * \sin\dfrac{\varphi}{2}. \end{cases} \quad (3)$$

The beginning of the coordinate system x_r, y_r is located on the pitch line $a-a$ at the point of contact with point P' from the pitch circle. The distance from the pitch point P to the beginning of the coordinate system x_r, y_r is equal to $r * \varphi$. These equations allow finding the contact ratio of CPRM. The last point of the line of action is determined by the height of the rack teeth, i.e from the tooth addendum $h_a = h_a^* * m$. So angle φ is determined by equation (3) for coordinate y

$$h_a = \left(2 * r * \sin\frac{\varphi}{2} - r_p\right) * \sin\frac{\varphi}{2} \quad (4)$$

All parameters of meshing are defined by module m: $h_a = h_a^* * m$; $r = \frac{m * z}{2}$; $r_p = r_p^* * m$. For irresponsible gears usually $h_a^* = 1$; $r_p^* = 0.5$ is used, i.e. the tooth addendum is equal to the diameter of the pin $h_a = d_p$. For the heavy-loaded gears empirical relationships are developed for selecting the parameters of meshing [9]: $h_a = m * (1 + 0.03 * z_1)$; $d_p = 1.67 * m$, number of teeth $z = 8...12$. Thus $h_a^* = 1 + 0.03 * z_1 \approx 1{,}3$; $r_p^* = 0.835$. In view of this equation (4) type extraction

$$h_a^* = \left(z * \sin\frac{\varphi_\alpha}{2} - r_p^*\right) * \sin\frac{\varphi_\alpha}{2} \quad (5)$$

From (5) determines the angle φ_a at which the rack tooth tip touches the pin

$$\varphi_\alpha = 2 * \arcsin\frac{r_p^* + 2 * \sqrt{h_a^* * z}}{2 * z} \quad (6)$$

The analysis of relationship (6) shows that the number of teeth z causes the biggest influence on angle φ_α. But according to the recommendations of [9], the number of teeth is changing in a small range $z = 8...12$, and so the angle φ is influenced mainly by the addendum factor h_a^*. The contact ratio is determined by the formula (7).

$$\varepsilon = \frac{\varphi}{\frac{2 * \pi}{z}} . \qquad (7)$$

The contact ratio in this case is determined on the basis that the pressure line is right

$$g_\alpha^2 = \left(r + h_a\right)^2 - r^2$$
$$g_\alpha = \sqrt{\left(r + h_a\right)^2 - r^2} . \qquad (8)$$

The contact ratio ε_α is equal to

$$\varepsilon_\alpha = \frac{g_\alpha}{\pi * m} . \qquad (9)$$

After replacing g_α and considering that $r = \frac{m * z}{2}$ and $h_a = h_a^* * m$ occurs

$$\varepsilon_\alpha = \frac{\sqrt{\left(\frac{z}{2} + h_a^*\right)^2 - \left(\frac{z}{2}\right)^2}}{\pi} . \qquad (10)$$

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