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TREADMILL WITHOUT THE IMPACT MECHANISM FOR GENERATING THE FORCES OF INERTIA ROLLERS

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This study is aimed at improvement of the vibrating rollers efficiency by means of asymmetrical planetary vibration exciters, are characterized by the higher level of dynamic parameters indicating how the energy being supplied to the vibration drum affects the increase of disturbing force and sealing capacity of the road rollers. To achieve the above goal several studies were conducted and one of their objectives was to develop the method of determination of the vibration exciter road rollers transition point junction that meets the integrity, tangency and curvature requirements. The original methodology of the specification of the combined race track shape composed by conic arcs and linked by easy curve was developed.

Let us consider the planetary vibration exciter (figure 1) with the race track composed by half-arcs of the circle with the radius a and ellipse with semi-axles a and b. Junction points $A(a,0)$ and $A'(-a,0)$ are located along the axle Ox. The circle has a curvature radius $\rho = a$, and the ellipse radius is $\rho = (b^4x^2 + a^4y^2)^{3/2} / a^4b^4$.

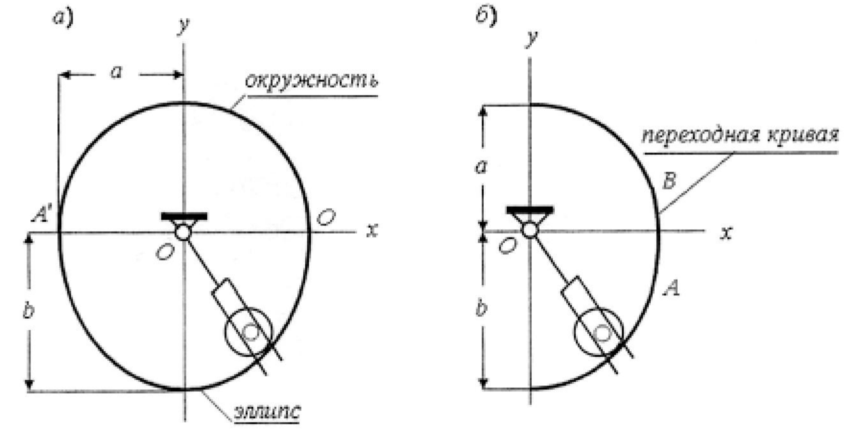

Fig. 1. Vibration exciter with combined race track

The vibration exciter runner wheel moves along race track composed by conic arcs with common tangents in junction points. When passing from one part of the track to another we have discontinuity in the curvature that causes jump of centrifugal force. To avoid such force jump it is necessary to insert special arc -curve shaped transition part (Figure 1b) meeting following requirements: a) the ach should pass through junction points A and B; b) connecting and connected parts should have equal first derivative in junction points; c) curvature radiuses in junction points should be equal . The junction that meets the requirements a) and b) corresponds to the first degree of smoothness. The junction that meets the requirements a), b) and c) corresponds to the second degree of smoothness [1]. Let us consider the objective of achieving of the smooth curve.

Liming showed [2], that it is possible to derive the equation of conic with two preset tangents passing through the third point:

$$(1-\lambda)\cdot L_1 \cdot L_2 + \lambda \cdot L_3^2 = 0 \qquad (1)$$

is a pencil of conics, passing through points A and B, here the line $L_2 = 0$ - s the tangent in the point A, and the line $L_1 = 0$ - is the tangent in the point B, nd the line $L_3 = 0$ - is a chord linking points A and B (fig. 2). The parameter λ is determined by setting up the point $M(x_M, y_M)$ then

$$\lambda = \frac{L_1(x_M, y_M)L_2(x_M, y_M)}{L_1(x_M, y_M)L_2(x_M, y_M) - L_3^2(x_M, y_M)}. \qquad (2)$$

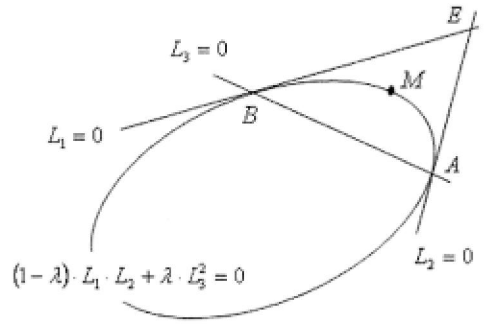

Fig. 2. Conic

Thus, conic equations of race track transition part are defined by four points: two junction points A and B; tangents intersection point E; a point M. By selecting point M inside ΔAEB we define the first smoothness degree curve between points A and B. Variants of race track transition part conics, connecting arches of the circle $x^2 + y^2 = 30^2$ and the ellipse $x^2/30^2 + y^2/40^2 = 1$ in points A(27; –17.44) and B(25; 16.58) are shown in the Fig. 3. In the semiarches junction point D the jump of curvature radiuses is observed: 1. For the arch with $\lambda = 0.035$: $\rho_A = 26.38$, $\rho_B = 13.4$; 2. For the arch with $\lambda = 0.025$: $\rho_A = 28.68$, $\rho_B = 23.23$ Use of Liming method allows to derive the expression describing connecting arch in form of the (1), provided the following five values are preset: 1,2) - two frontier points, satisfying the equation (1); 3,4) - two

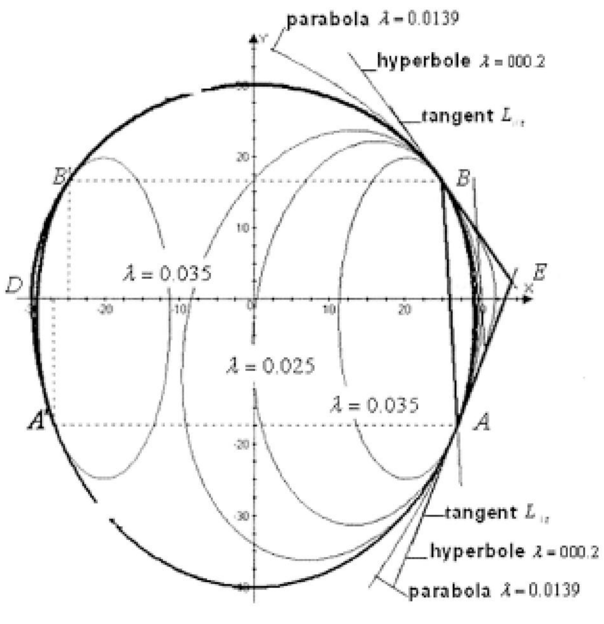

Fig. 3. Pencil of conics

tangentials, passing through the frontier points; 5) - λ-parameter, determined by the (2).

Resultant curve arch provides smoothness of the first grade. Proper selection of λ-parameter in the equation (1) allows to obtain curve shape satisfying the required smoothness condition. That is, the conic derived by the Liming method in points A and B should have curvature radiuses equal to the preset ρ_A and ρ_B. For this purpose it is necessary to determine relations between curve radius and λ parameter. Actually, [3] often the conic is preset by two lines tangent to it, and tangent points on them, plus one other point or by presetting λ-parameter. It is more practically useful to preset the conic by two lines tangent to it, and tangent points on them, and the engineering discriminant (Fig. 4). In case of engineering method, the point M on the curve between points A and B is preset as the cross point of the median CE of the basic triangle ΔAEB with the target curve. In this case, point M is defined by the segment CM (cut off on median from the median base) to the median CE value ratio: $f = CM/CE$ and is called the engineering discriminant. The radius of the curvature in the point A is determined as [1]:

$$\rho_A = (2f^2 l_A^2)/((1-f)^2 h_B), \qquad (3)$$

where $l_A = AE$ is the length of the tangent, passing from the point A through to the point E, h_B - is the distance from the point B to the tangent in the point A.

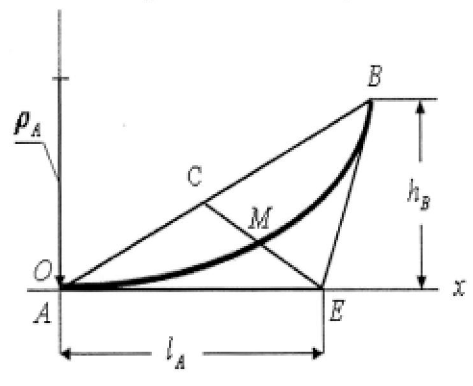

Fig. 4

Let us assume that the transition part $\cup AMB$ has elliptic shape (fig. 5). Let us consider points $A(x_A, y_A)$ and $B(x_B, y_B)$ with ρ_A and ρ_B correspondingly and draw tangents $L_{A\tau}$ и $L_{B\tau}$ passing through them, these tangentials shall meet at the point E. By connecting points A, B and E we draw the basic triangle ΔAEB, which is formed by tangents $L_{A\tau}$, $L_{B\tau}$, chord L_{AB}, ED - is a median. Let us

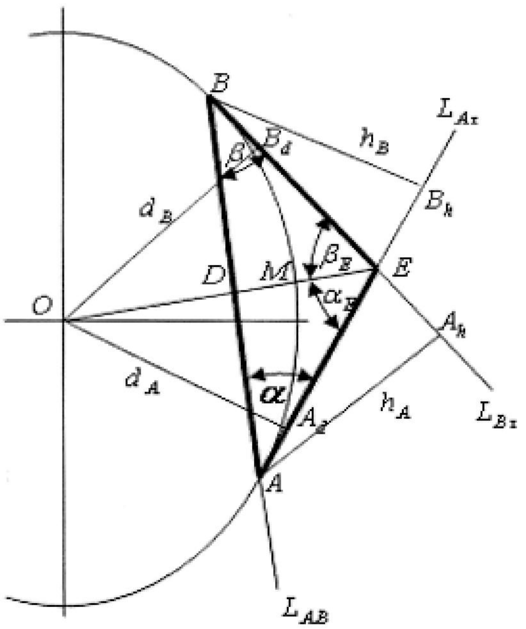

Fig. 5. Basic Triangle

denote the distances from the center O to $L_{A\tau}$ and $L_{B\tau}$, as $l_B = BE$, $d_A = OA_d$, $d_B = OB_d$; and $h_A = AA_h$, $h_B = BB_h$ are the distances from points A and B to $L_{B\tau}$ and $L_{A\tau}$, $\alpha = \angle BAE$, $\beta = \angle ABE$, $\alpha_E = \angle AED$, $\beta_E = \angle BED$. It is known that the ellipse radius in a point equals to [4]: $\rho_A = a^2b^2/d_A^3$, $\rho_B = a^2b^2/d_B^3$. By using the above, let us introduce the radiuses ratio $\eta = \sqrt[3]{\rho_A/\rho_B} = d_B/d_A$. Ratio η shall play the leading part in deriving smooth joint curve. Let us consider the triangles ΔOA_dE and ΔOB_dE, in this case $\sin\beta_E/\sin\alpha_E = d_B/d_A = \eta$. Let us consider triangles ΔADE and ΔBDE, applying theorem of sins, in this case we get $\sin\beta_E/\sin\alpha_E = \sin\beta/\sin\alpha = \eta$. For triangles ΔAEB, ΔAA_hB and ΔAB_hB we obtain $\sin\beta/\sin\alpha = l_A/l_B = h_A/h_B = \eta$. Thus, in case we have two A and B of the ellipse with curvature radiuses of ρ_A and ρ_B, the ratio between corresponding elements of the ΔAEB and η is:

$$\frac{\sin\beta}{\sin\alpha} = \frac{\sin\beta_E}{\sin\alpha_E} = \frac{d_B}{d_A} = \frac{l_A}{l_B} = \frac{h_A}{h_B} = \sqrt[3]{\rho_A/\rho_B} = \eta. \quad (4)$$

The above ratios allow determining the junction area where the smooth transition from one part to another. Let us assume that the arch of the transition area $\cup AMB$ is the part of the drum roller with the combined shape consisting of arcs of circle and ellipse. Let us select a point A on the given ellipse with the radius of the curvature ρ_A and set it as a zero of the fixed coordinate system Ax_1y_1. Axis Ax_1 is directed along $L_{A\tau}$ tangential to ellipse at this point A, and axis Ay_1 is directed along normal L_{An} (fig. 6). The radius of curvature of any B in this circle equals to $\rho_B = r$. The tangent $L_{B\tau}$, drawn through the B, crosses tangent $L_{A\tau}$ in the E. When changing the position of the point B each time a new tangent to the circle from the new position of the point B is drawn and this leads to the change of the position of the point E in the axis Ax_1.

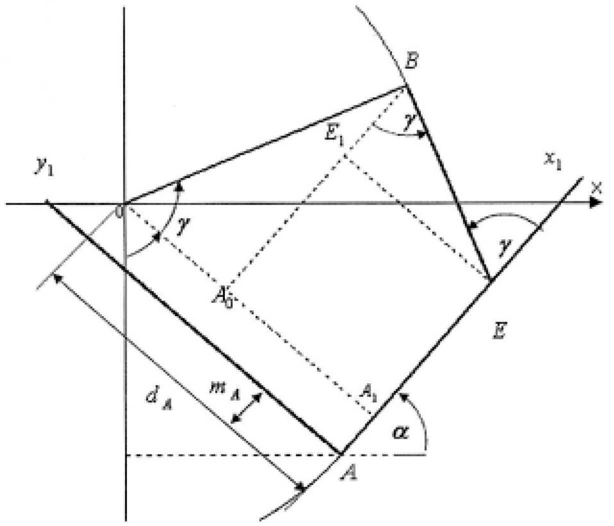

Fig. 6

Thus by changing the slope angle γ of tangential $L_{B\tau}$ relatively to the fixed axis Ax_1, we can determine the position of the point B in the circle. The angle γ should ensure the correspondence with the type ratio (4). We propose to simulate the process of determination of the point B position by use of the link mechanism, provided that the ratio (4) is correct. Stems OB and BE, normal and tangential to the circle at the point B and rigidly connected with each other at the point B at right angle, form the link OBE (fig. 7). Link sliding block E moves along the slot BE and is pin connected at the point E with the stem Ex_1 tangential to the ellipse at the point A. Rotation of the link OBE

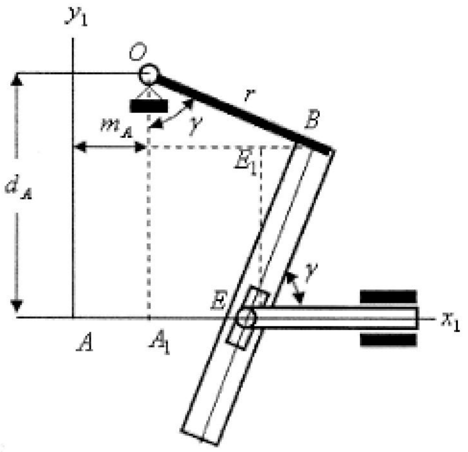

Fig. 7. Link mechanism

about the fixed point O in Ax_1y_1 plane sets in motion the block E and sliding of the latter along the slot BE in its turn causes translator motion of the stem Ex_1 along the axis Ax_1. Thus the block E all the time it moves stays at the intersection of the guiding lines BE and Ex_1. Such movement of the block E leads to the simultaneous change of the distances AE and BE. By deriving the motion equation of the block E is possible to fulfill the ratio $l_A/l_B = \eta$. The angle γ also determines the position of the link BE relative to the fixed axis Ax_1. Let us assume that d_A and m_A are the distances from the fixed pin O to the guiding line Ax_1 and the normal Ay_1, correspondingly. Then coordinates of the points E and B are:

$$\begin{cases} x_E = (m_A + r\sin\gamma) - d_A - r\cos\gamma/tg\gamma \\ y_E = 0 \end{cases}$$

and
$$\begin{cases} x_B = m_A + r\sin\gamma \\ y_B = d_A - r\cos\gamma \end{cases} \qquad (5)$$

Let us evaluate the length change as a function of the link rotation angle:

$$l_A = \frac{m_A tg\gamma\sqrt{1+tg^2\gamma} - d_A\sqrt{1+tg^2\gamma} + r(1+tg^2\gamma)}{tg\gamma\sqrt{1+tg^2\gamma}},$$

$$l_B = \frac{d_A\sqrt{1+tg^2\gamma} - r}{tg\gamma}.$$

With the provision for the ratio (4) we deduce the equation relatively to $k = \text{tg}\gamma$:

$$\frac{m_A k\sqrt{1+k^2} - d_A\sqrt{1+k^2} + r(1+k^2)}{\sqrt{1+k^2}\left(d_A\sqrt{1+k^2} - r\right)} = \eta. \quad (6)$$

Thus we have developed the method of determination of the shape of a combined race track, which is formed by conic arcs linked with each other by smooth curve. The algorithm of this method consists in the following: by the ratio (6) we obtain the value of $k = \text{tg}\gamma$ and γ, correspondingly. Then in accordance with (5) we determine the coordinates of the point E and B, basing on their values with the help of (3) we determine the value of f and fix the point M, by the latter we evaluate the parameter λ with the use of the formula (2). And finally, we deduce the equation of a smooth curve linking the ellipse and the circle in the points A and B using the parameters determined by the formula (1).

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Резюме

Зерттеу жұмысы жол тегістегіштердің тығыздау қабілетін және қажет ететін күштерді арттыру үшін діріл қоздырғышына түсетін энергияның әсерін сипаттайтын біршама жоғары деңгейдегі динамикалық параметрлерімен ерекшелентін асимметриялы планетарлы діріл қоздырғыштарды қолдана отырып, діріл тегістегіштердің тиімділігін жоғарылатуға бағытталды. Қойылған мақсаттарды орындау үшін берілген үзіліссіз және қисықтық шарттарын қанағаттандыратын діріл қоздырғышының жүру жолының ауысу аймағына қосылу орындарын анықтаудың әдістемелерін жасау мәселелері кіретін зерттеу жұмыстарын жүргізу арқылы жетуге болады. Доғамен және қисықтармен өзара біріктірілген жүру жолының пішінін анықтаудың ерекше әдістемесі жасалды.

Резюме

Исследование направлено на повышение эффективности вибрационных катков с использованием асимметричных планетарных вибровозбудителей, которые отличаются более высоким уровнем динамических параметров, характеризующих влияние подводимой к вибровальцу энергии на увеличение вынуждающей силы и уплотняющей способности дорожных катков. Выполнение поставленной цели достигалось проведением ряда исследований, одна из задач которого включала разработку методики определения мест соединения переходного участка беговой дорожки вибровозбудителя, удовлетворяющей заданным условиям нерерывности, касания и кривизны. Разработана оригинальная методика по определению формы комбинированной беговой дорожки, составленных из дуг коник и соединенных между собой плавной кривой.