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PROPOSALS FOR DETERMINING OPTIMAL MATERIAL FLOW FOR HIGH-CAPACITY CONVEYORS

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Abstract: The paper proposes the improvement of technological parameters for band conveyors. In order to determine the optimum capacity of band conveyers we start from the general equation, the vee profile of the material section on band is imposed, its equation is being determined, the bedding coefficient is being found out and its relation is further obtained for a maximum section of the material. The results obtained allow for the implementation of optimization algorithms for the band conveyers systems.

1. INTRODUCTION

The paper describes the aspects imposed by an issue of constructive and functional optimization and raised by the achieved programs. The notions of dynamic system are being defined and the limitations imposed to state variables (system), the mathematical model. In order to assess the quality of a system the enunciation procedure of the mathematical model shall be displayed and the establishment of variables and optimization criteria as well as their structure for the band conveyor continuous installations. The enunciation modality of the optimization issue and the solving methods for the actuation systems of belt conveyors shall be analyzed. In this case, the most used are the Euler-Lagrange algorithm, the Bellman Principle of dynamic programming and the Pontryagin's Maximum Principle for which the enunciation modality of the problem is being displayed, the limitations and the solving algorithm of the equation system.

2. PROPOSALS FOR DETERMINING THE OPTIMUM FLOW OF MATERIAL UNDER CONTINUOUS TRANSPORT BAND.

Knowing the current sectional area of material transported A, transport speed v, the specific gravity of loose material (or mass per meter of belt material) q_m, for a continuous transport belt installation, material flow is determined by the general equation of the continuous transport

$$Q = k_1 A v \gamma = k_2 v q_m \tag{1}$$

The section of the transported material is determined by width of the loaded tape b, the riverbed form and dynamic slope angle ρ_d, (fig. 1).

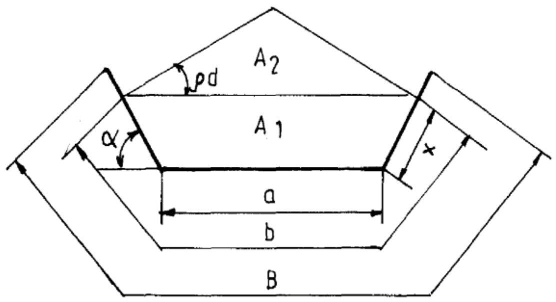

Figure 1. Cross section through the current material

Area determined by loaded tape on the support of three rolls is maximum if the area will be highest trapeze,

$$A_1 = (a + x\cos\alpha)\,x\sin\alpha = (b - 2x + x\cos\alpha)\,x\sin\alpha \tag{2}$$

where, α is the side rollers angle and x is the bandwidth inclined on the side rollers.

Extremely necessary condition (for section) will be expressed by the equations resulting from the cancellation first order partial derivatives of the section considered in relation to the variables α and x.

$$\begin{aligned}
\frac{\partial A}{\partial \alpha} &= x^2\left(\cos^2\alpha - \sin^2\alpha\right) + (b - 2x)\cos\alpha = 0 \\
\frac{\partial A}{\partial \alpha} &= (-2 + \cos\alpha)\,x\sin\alpha + (b - 2x + x\cos\alpha)\sin\alpha = 0
\end{aligned} \tag{3}$$

Solving the system of equations (3) we obtain the optimal values, $\alpha^* = \frac{\pi}{3}, \chi^* = \frac{6}{3}$.

Calculating the second order derivatives of the considered section,

$$\begin{aligned}
\frac{\partial^2 A}{\partial x^2} &= -2x^2\sin 2\alpha - x(b - 2x)\sin\alpha \\
\frac{\partial^2 A}{\partial \alpha\,\partial x} &= 2x\cos 2\alpha + (b - 4x)\cos\alpha \\
\frac{\partial^2 A}{\partial x^2} &= 2(-2 + \cos\alpha)\sin\alpha
\end{aligned} \tag{4}$$

Hessian matrix is built for optimal results $(\pi/3, b/3)$:

$$H = \begin{bmatrix} -\frac{\sqrt{3}}{6}b^2 & -\frac{b}{2} \\ -\frac{b}{2} & -\frac{3\sqrt{3}}{2} \end{bmatrix} \tag{5}$$

Because, according to Sylvester condition, main diagonal minors are,

$$\Delta_1 = -\frac{\sqrt{3}}{6}b^2 < 0, \qquad \Delta_2 = \frac{1}{2}b^2 > 0 \tag{6}$$

This extremely is a maximum, which will correspond to the maximum theoretical section. Current section of material is determined by geometric characteristics of the support of route. Considering three-roller support, the total area of the current material has the following expression:

$$A = \frac{tg\,\rho}{4}\left[a + (b-a)\cos\alpha\right]^2 + \frac{2a + (b-a)\cos\alpha}{2}\,\frac{b-a}{2}\sin\alpha \tag{7}$$

The whites coefficient, can be determined from the condition of maximum section, $\frac{dA}{dk} = 0$.

The condition for maximizing the cross-sectional area is obtained:

$$k = \frac{(\sin\alpha + \cos\alpha\; tg\,\rho)(1-\cos\alpha)}{(2-\cos\alpha)\sin\alpha + tg\,\rho(1-\cos\alpha)^2} \tag{8}$$

The maximum value for the area is obtained for, $a = \frac{b}{3}$, so we plot the coefficient of whites, according to the angles α and $tg\,\rho$, namely:

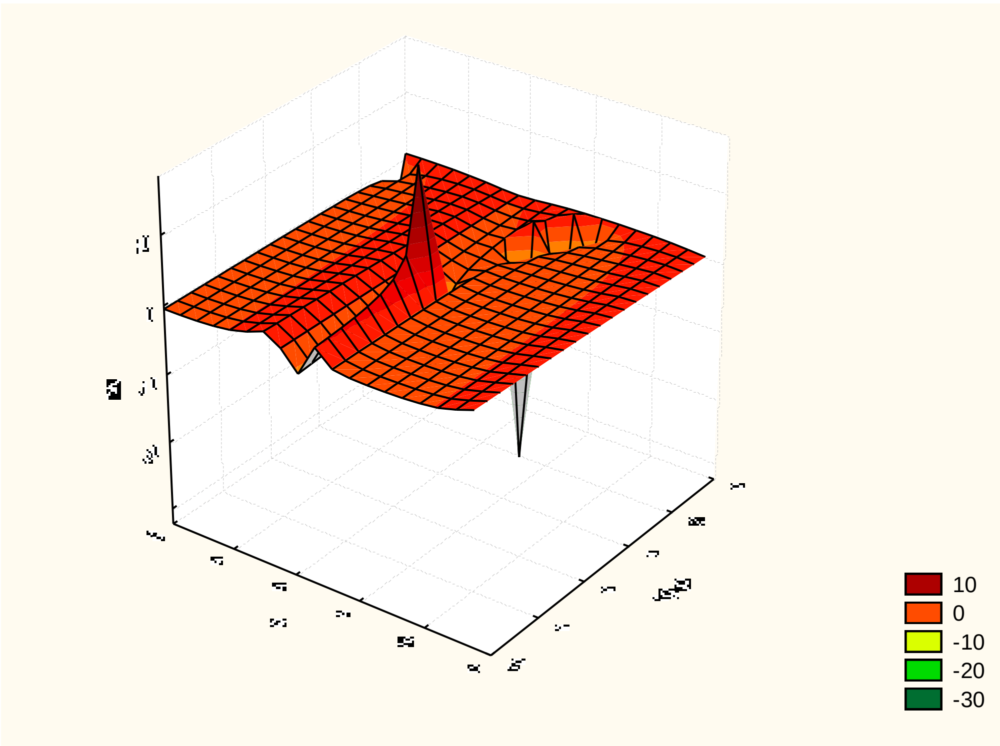

Figure 2. Ratio of whites dependency by α and $tg\,\rho$ variables

Can be considered, $a \approx 0.44\,b$. Thus the expression 7 becomes:

$$A = \frac{b^2}{4}\left[\left(0,44 + 0,56\cos\alpha\right)^2 tg\rho + \left(0,493 + 0,314\cos\alpha\right)\sin\alpha\right] \tag{9}$$

We plot area, depending on b and ρ, as follows:

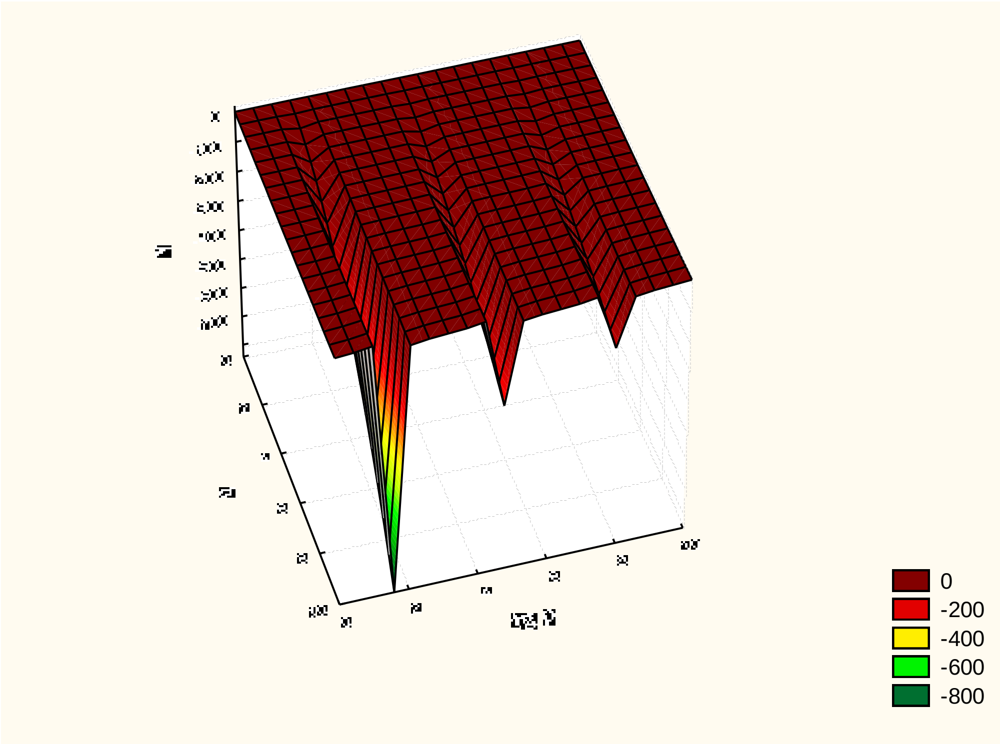

Figure 3. Area dependency by α and ρ variables

3. CONCLUSIONS

Analyzing the transport process, maximum cross section should be provided to achieve maximum flow transported.

Algorithm for determining the optimal flow will involve the band parameters, depending on which to determine the optimum speed to ensure maximum flow transport.

Therefore, the optimization of constructive parameters of the band conveyor continuous installations supposes the use of an on-line processed database, necessary for controlling their operating dynamic regime in the sense of improving the technological parameters for the conveyer band.

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