ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
Tome V (Year 2012). FASCICULE 3 [July–September]. ISSN 2067-3809

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THE DETERMINATION OF THE ELECTRIC MOTOR POWER THAT DRIVES THE BELT TRANSPORT CONVEYERS

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ABSTRACT: *The paper introduces an analytical method to determine the electric motor power that drives horizontal and inclination belt transport conveyers, with and without deviation drums. To compute the electric motor power we used the permitted load, the proper weight of the belt, the advancing strength introduced by the support rolls and the supplementary inclination determinate by the winding on the return drum. The algorithm for electric motor power that drives the belt transport conveyors it was establish in the paper. The paper introduces on the base of studying spatiality literature may be present the method of calculation for motor power that drives the belt transport conveyers with slow and medium capacity.*
KEYWORDS: *electric motor power, belt transport conveyers, analytical method, algorithm*

INTRODUCTION

The paper introduces on the base of studying spatiality literature [1-4] may be present the method of calculation for motor power that drives the belt transport conveyers with slow and medium capacity. For this, it can do from mechanical tensions from the belt of transport conveyor, in the case of conveyers with and without deviation drums, after which it may determine the reduced resistant moments to shafts of drive motors, and then may be calculate the necessary power for motors. It may be considered that the belt transport conveyers are drive with triphasic cage induction motors [5-7].

THE DETERMINATION OF REDUCED RESISTANT MOMENTS AT MOTOR SHAFT

The tensions in the belt, for inclined transport conveyer with β>0, without deviation drum (fig.1), in points 1, …, 4 are:

$$S_1 = S_x \ [N] \tag{1}$$

$$S_2 = S_x + (q_b + q_{rg})\cdot L\cdot w\cdot\cos\beta - q_b\cdot L\cdot\sin\beta \ \ [N] \tag{2}$$

$$S_3 = k_{\hat{i}}\cdot S_2 \ \ [N] \tag{3}$$

$$S_4 = S_3 + (q_b + q_{\hat{i}} + q_{rp})\cdot L\cdot w\cdot\cos\beta + (q_b + q_{\hat{i}})\cdot L\cdot\sin\beta \ [N] \tag{4}$$

In these relations, the tension S_x in point of band detach from motor drum does not know, q_{rp} [N/m] and q_{rg} [N/m] are uniform distribute weights for mobile parts of the superior train rolls, respective for the inferior, w[-] it is the specific resistance to movement of the band (w=0,03…0,05 for the pipe rolls) and $k_{\hat{i}}$ [-] it is a coefficient which put in the evidence the contribution of return and deviation drums, at modify the band tensions.

The uniform charge weights q_{rp} şi q_{rg} may be calculate with:

$$q_{rp} = \frac{G_{rp}}{l_1} \tag{5}$$

$$q_{rg} = \frac{G_{rg}}{l_2} \tag{6}$$

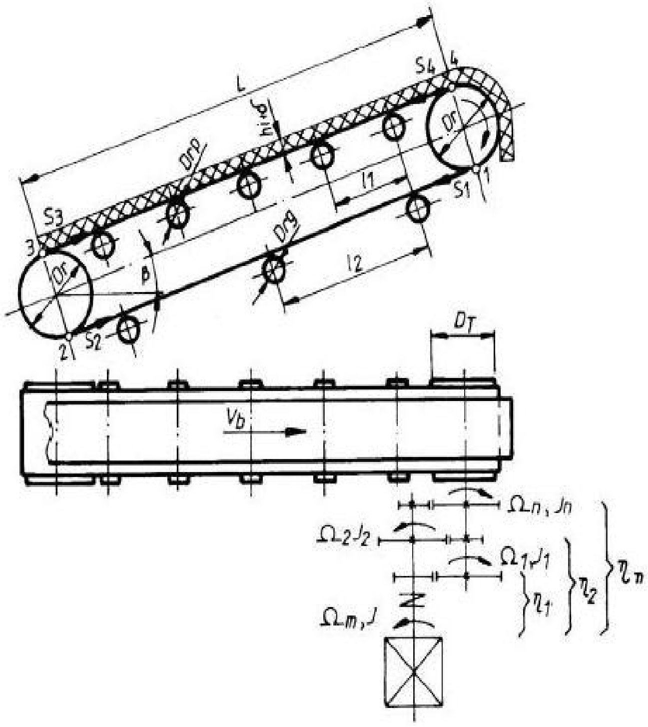

Fig.1. Belt inclinator transport conveyer without deviation drum

where G_{rp} [N] and G_{rg}[N] are the weight of movement parts of superior train rolls, respective of inferior train rolls.

The coeficient $k_{\hat{i}}$ takes values by 1,05…1,07 for the wrap up angles by 180°, and 1,03…1,05 for the wrap up angles by 90°, and 1,02…1,03 the wrap up angles smaller than 90°.

The Euler ecuation about the condition of unslip of the band on motor drum is:

$$k_f \cdot S_4 = S_1 \cdot e^{\mu \cdot \alpha} \quad [N] \tag{7}$$

where k_f[-] is the safety coefficient for unslip on motor drum (k_f=1,2…1,3), e is the base of naturals logarithms, μ [-] is the friction coefficient between the band and the driven drum (μ=0,25…0,35) and α[rad] it is the angle of wrap up for the band on motor drum. With relations (1),…, (4) and (6) may be get:

$$S_1 = \frac{k_f \cdot L \cdot \left\{ \begin{array}{l} w \cdot \cos\beta \cdot \left[q_b \cdot (1+k_î) + k_î \cdot q_{rg} + q_î + q_{rp}\right] \\ + \sin\beta \cdot \left[q_b \cdot (1-k_î) + q_î\right] \end{array} \right\}}{e^{\mu \cdot \alpha} - k_f \cdot k_i} \quad [N] \tag{8}$$

$$S_4 = k_î \cdot S_1 + \frac{S_c}{k_f} \quad [N] \tag{9}$$

The reduce resistant moments for motor shaft may be obtioned with:

$$M_{rr} = \frac{(S_4 - S_1)}{\eta_R \cdot i} \cdot \frac{D_T}{2} \quad [Nm] \tag{10}$$

where the tensions in band S_1 and S_2 are from expressions (8) and (9).

For horizontal transport conveyers, without deviation drums when β=0 and from expressions (8) and (9) result:

$$S_1 = \frac{k_f \cdot L \cdot w \cdot \left[q_b \cdot (1+k_î) + k_î \cdot q_{rg} + q_î + q_{rp}\right]}{e^{\mu \cdot \alpha} - k_f \cdot k_î} \quad [N] \tag{11}$$

$$S_4 = L \cdot \left\{ k_î \cdot S_1 + w \cdot \left[\begin{array}{l} q_b \cdot (1+k_î) \\ + k_î \cdot q_{rg} + q_î + q_{rp} \end{array} \right] \right\} \quad [N] \tag{12}$$

The reduce resistance moments at motor shaft, may be determinate with the formula (10) where S_1 and S_2 are given by expression (11) and (12).

The reduce resistance moments at shaft of driven motor, may be determinate for the belt transport conveyer with deviation drum is presented in fig.2.

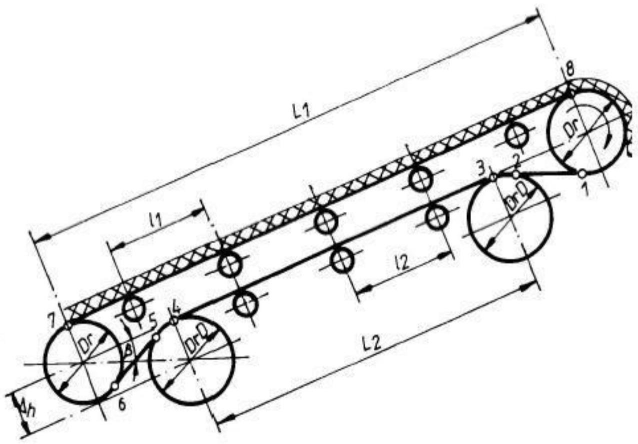

Fig.2. Belt inclinated transport conveyer with deviation drum

The tensions in band, in points 1,…,8, for β>0 are:

$$S_1 = S_x \quad [N] \tag{13}$$

$$S_2 \approx S_1 \quad [N] \tag{14}$$

$$S_3 = k_{î1} \cdot S_2 \quad [N] \tag{15}$$

$$\begin{array}{l} S_4 = S_3 + (q_b + q_{rg}) \cdot L_2 \cdot w \cdot \cos\beta \\ - q_b \cdot L_2 \cdot \sin\beta \end{array} \quad [N] \tag{16}$$

$$S_5 = k_{î1} \cdot S_4 \quad [N] \tag{17}$$

$$S_6 \approx S_5 \quad [N] \tag{18}$$

$$S_7 = k_{î2} \cdot S_6 \quad [N] \tag{19}$$

$$\begin{array}{l} S_8 = S_7 + (q_b + q_î + q_{rp}) \cdot L_1 \cdot w \cdot \cos\beta \\ + (q_b + q_î) \cdot L_1 \cdot \sin\beta \end{array} \quad [N] \tag{20}$$

where $k_{î1}$ [-] it is the band loading coefficient because the band passing over deviation drums ($k_{î1}$=1,02…1,03) and $k_{î2}$[-] it is the band loading coefficient over return drum ($k_{î2}$=1,07…1,09).

The band loading that passing over deviation drums have some coefficients values, because the angles of wrap up of band on these drums are equal.

The condition by unslip of band on motor drum is:

$$k_f \cdot S_8 = S_1 \cdot e^{\mu \cdot \alpha} \tag{21}$$

With these expressions (13),…,(21) may be get the next ecuations:

$$S_1 = \frac{k_f \cdot S_A}{e^{\mu \cdot \alpha} - k_{î1}^2 \cdot k_{î2} \cdot k_f} \quad [N] \tag{22}$$

$$S_8 = S_1 \cdot k_{î1}^2 \cdot k_{î2} + S_A \quad [N] \tag{23}$$

where S_A has this formula:

$$\begin{array}{l} S_A = w \cdot \cos\beta \cdot \left(\begin{array}{l} q_b \cdot (L_1 + k_{î1} \cdot k_{î2} \cdot L_2) \\ + q_{rg} \cdot k_{î1} \cdot k_{î2} \cdot L_2 + L_1 \cdot (q_î + q_{rp}) \end{array} \right) \\ + \sin\beta \cdot (L_1 \cdot (q_b + q_î) - k_{î1} \cdot k_{î2} \cdot q_b \cdot L_2) \end{array} \tag{24}$$

For horizontal transport conveyer (β=0) with band deviation drums, the tensions S_1 and S_8 from the band are:

$$S_1 = \frac{k_f \cdot S_B}{e^{\mu \cdot \alpha} - k_{î1}^2 \cdot k_{î2} \cdot k_f} \quad [N] \tag{25}$$

$$S_8 = S_1 \cdot k_{î1}^2 \cdot k_{î2} + S_B \quad [N] \tag{26}$$

where S_B may be calculate with:

$$S_B = w \cdot \left[\begin{array}{c} q_b \cdot (L_1 + k_{î1} \cdot k_{î2} \cdot L_2) \\ + q_{rg} \cdot k_{î1} \cdot k_{î2} \cdot L_2 \\ + L_1 \cdot (q_î + q_{rp}) \end{array} \right] \tag{27}$$

For these two situations (β>0 and β=0) the reduced resistant moments at motor shaft may be compute with:

$$M_{rr} = \frac{(S_8 - S_1)}{\eta_R \cdot i} \cdot \frac{D_T}{2} \quad [Nm] \tag{28}$$

In the relations (10) and (28) i is the transmition ratio of reduction devices:

$$i = \frac{\Omega_m}{\Omega_T} \quad (29)$$

where $\Omega_m[s^{-1}]$ and $\Omega_T[s^{-1}]$ are the angular speeds of the motor and the driven drum.

THE NECESSARY POWER CALCULATION FOR DRIVING THE BELT TRANSPORT CONVEYERS

The necessary power for driving the belt transport conveyer may be calculate with:

$$\begin{aligned} P_T &= M_{rr} \cdot \Omega_m \cdot 10^{-3}; \\ P_T &= M_{rr} \cdot i \cdot \Omega_T \cdot 10^{-3}; \ [kW] \\ P_T &= M_{rr} \cdot i \cdot \frac{v_b}{R_T} \cdot 10^{-3} \end{aligned} \quad (30)$$

where v_b [m/s] is the band speed and R_T [m] is the ray of driven drum.

May be choise a motor which has the nominal speed n_n [rot/min]:

$$n_n \geq \frac{30 \cdot \Omega_m}{\pi} \quad (31)$$

and the power:

$$P_n \geq P_T \quad (32)$$

In continuation it is checking if the starting motor moment M_p [Nm] is bigger than the reduced resistant moment M_{rr} [Nm] at shaft of driven motor. For this, from the motor catalog, it is determining the variation of the motor moment in function with the slip s[-].

The motor moment is giving by simplification ecuation of Kloss:

$$M = \frac{2 \cdot M_k}{\frac{s}{s_k} + \frac{s_k}{s}} \quad (33)$$

where: M_k [Nm] is the critical motor moment, s_k [-] - the slip at the critical moment and s[-] is the motor slip. These size are calculating with:

$$\begin{aligned} M_k &= \lambda \cdot M_n; \\ M_k &= \lambda \cdot \frac{P_n}{\Omega_n}; \\ M_k &= \lambda \cdot \frac{30 \cdot P_n}{\pi \cdot n_n} \end{aligned} \quad (34)$$

$$\begin{aligned} s_k &= s_n \cdot \left(\lambda + \sqrt{\lambda^2 - 1}\right); \\ s_k &= \frac{n_o - n_n}{n_o} \cdot \left(\lambda + \sqrt{\lambda^2 - 1}\right); \\ s_k &= \frac{\Omega_o - \Omega_n}{\Omega_o} \cdot \left(\lambda + \sqrt{\lambda^2 - 1}\right) \end{aligned} \quad (35)$$

$$\begin{aligned} s &= \frac{n_o - n}{n_o}; \\ s &= \frac{\Omega_o - \Omega}{\Omega_o} \end{aligned} \quad (36)$$

$$\begin{aligned} s_n &= \frac{n_o - n_n}{n_o}; \\ s_n &= \frac{\Omega_o - \Omega_n}{\Omega_o} \end{aligned} \quad (37)$$

In this relations:

λ[-] is the motor overload coefficient gave it in the motor catalog,

P_n [W] is the motor nominal power,

n_o [rot/min] and Ω_o [s^{-1}] are the syncronic speed, respective the angular speed proper at this speed,

n_n [rot/min] and Ω_n [s^{-1}] are the nominal speed, respective the angular speed,

n [rot/min] and Ω [s^{-1}] are the momentan speed, respective the angular speed and

s_k[-], s_n[-] and s[-] are the slip proper for the critical moment M_k, nominal moment M_n and current moment M.

The motor starting moment M_p [Nm] are calculating with sympliphicate formula of Kloss for s=1:

$$M_p = \frac{2 \cdot M_k \cdot s_k}{1 + s_k^2} \quad (38)$$

The motor may win the dynamic moment M_d [Nm] if:

$$M_p > M_{rr} \quad (39)$$

If this condition is not carries out, may be choise a motor with bigger power.

CONCLUSIONS

This paper introduces on the base of investigation done it on spatiality literature [1-7], a quick calculation of necessary power for drive with triphasic cage induction motors the inclined or horizontal belt transport conveyer, with and without deviation drums.

For inclined or horizontal belt transport conveyer without deviation drums, the necessary power of driven motor are calculating with (30), (8), (9), (11), (12) and (10), and for inclined or horizontal transport conveyer with deviation drums, the necessary power of driven motor are calculating with (30), (28), (24), (22), (23) or (27), (26), (25) and (28) with carry out of inequality (39), for these two constructive types.

In this work may be establish the algorithm and the computing program of power driven motor for belt transport conveyer with small and medium capacity.

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ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING

ISSN: 2067-3809 [CD-Rom, online]