COMPARISON OF THE METHODOLOGIES FOR THE DETERMINATION OF THE BELT TENSIONS AND THE REQUIRED DRIVE POWER OF THE BELT CONVEYORS

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ABSTRACT. Four methodologies are discussed: short and precise methodology of the Design, Science and Research Institute for Industrial Transport (Protransniiproekt), Russia; short and precise methodology according to the German calculation standard for belt conveyors DIN 22101.
The calculations are accomplished using the four methodologies for a concretely solved example - a stationary all-purpose belt conveyor with assigned layout profile, type and characteristic of the transported material, capacity, belt width and belt velocity, linear mass of the material, the belt and the idlers. In the calculations an equal coefficient of motional resistance and an equal coefficient of friction between the belt and the drive pulley are assumed. The belt tensions at start-up and at steady state working and the required drive power are determined.
The following conclusions are drawn: 1. Approximately equal values are obtained for the required drive power; 2. Smaller values are obtained for the belt tensions in the precise methodology in comparison with the short methodology. 3. Higher values are obtained for the belt tensions in the DIN methodology in comparison with the Protransniiproekt methodology. The reason is the difference in the methods for determination. 4. It should be noticed that the coefficient of motional resistance in the Promtransniiproekt methodology is recommended to be taken greater in comparison with the DIN methodology, which will lead to the increase of the belt tensions.

Keywords: belt tensions, drive power, methodology

СРАВНЯВАНЕ НА МЕТОДИКИТЕ ЗА ОПРЕДЕЛЯНЕ НА СИЛИТЕ НА ОПЪН В ЛЕНТАТА И МОЩНОСТТА НА ЗАДВИЖВАНЕТО НА ЛЕНТОВИТЕ ТРАНСПОРТЬОРИ

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РЕЗЮМЕ. Разгледани са четири методики: приблизителна и уточнена методика на проектанстския и научно-изследователски институт за промишлен транспорт (Промтрансниипроект), Русия; приблизителна и уточнена и методика по немския стандарт за изчисляване на лентови транспортьори DIN 22101.
Направени са изчисления по четирите методики за конкретно решаван пример - стационарен общопромишлен транспортьор със зададени профил на трасето, вид и характеристика на транспортирания материал, производителност, ширина и скорост на лентата, линейни маси на материала, лентата и ролковите опори. При изчисленията е приет еднакъв коефициент на съпротивление при движението на лентата и еднакъв коефициент на триене между лентата и задвижващия барабан. Определени са силите на опън в лентата при пусков и установен режим и необходимата мощност на задвижването.
Направени са следните изводи: 1. За необходимата мощност на задвижването се получават близки по значение стойности; 2. За силите на опън в лентата при уточнената методика се получават по-малки стойности в сравнение с приблизителната методика; 3. За силите на опън в лентата по двете уточнени методики при методиката на DIN се получават по-големи стойности. Причина за това е разликата в начина им на определяне; 4. Трябва да се отбележи, че по методиката на Промтрансниипроект се препоръчва коефициентът на съпротивление при движение да се приема по-голям в сравнение с методиката на DIN, което ще доведе до увеличаването на силите на опън.

Ключови думи: сили на опън в лентата, мощност на задвижването, методика

Introduction

There are different methodologies for the calculation and the design of the belt conveyors - the American standards ISO and CEMA, the German standard DIN, Russian methodologies, etc. Because of the differences in the methods for the determination of some parameters it will be useful tohave a comparative evaluation of the calculation results using these methodologies.

The present research is a continuation of a previous research, in which the calculation results of the material cross section area and the capacity of the belt conveyor using three methodologies are compared (Journal of Mining and Geological Sciences, 2018).

The calculations in the present paper are accomplished using the following methodologies: the methodologies of the Design, Science and Research Institute for Industrial Transport Promtransniiproekt, Russia - short and precise methodology (Posobie po proektirovaniyu konveyernogo transporta,1988); the methodologies according to the German standard for belt conveyor design DIN 22101 - short and precise methodology (Dunlop conveyor belt design and calculation, Phoenix conveyor belt design fundamentals, 2004).

The aim of the present research is to calculate the belt tensions at start-up and at steady state working and the required drive power using the four methodologies and to compare the results. A concrete example is solved for a conveyor with a given layout profile, type and characteristic of the transported material, capacity, belt width and belt velocity, linear masses of the belt, the material and the idlers. In the calculations an equal coefficient of motional (primary) resistance and an equal friction coefficient between the belt and the drive pulley are assigned.

Determination of the belt tensions and the required drive power using the different methodologies

Input data for the design

The calculations in the present research are accomplished for a stationary belt conveyor with the following parameters: length of the horizontal projection of the conveyor L_r = 200m; lifting height H = 24 m; transported material limestone with density ρ = 1,5 t/m^3; belt width B = 800 mm; belt velocity v = 1.6 m/s.

Determination of the geometric parameters of the layout profile of the conveyor (according to Fig.1)

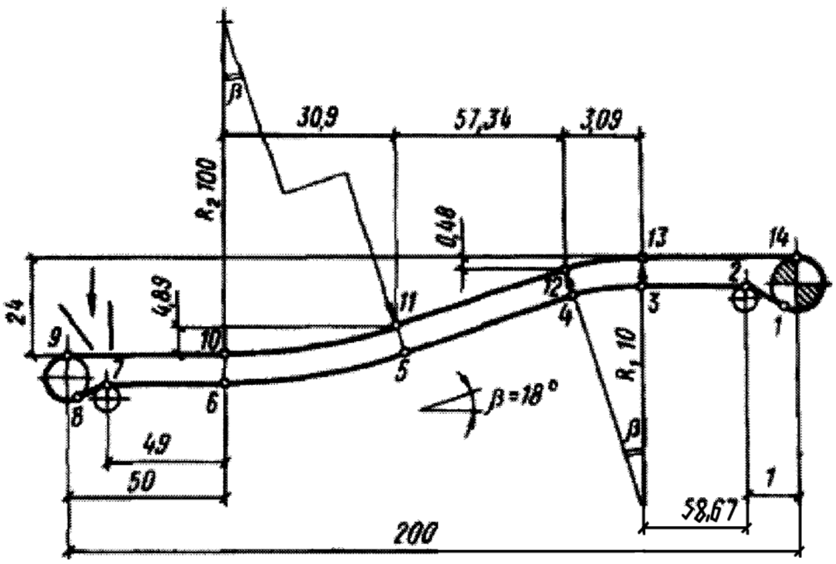

Fig.1. Scheme of the layout profile of the conveyor

Initially it is assumed: angle of inclination of the conveyor β = 18° (the maximum permissible angle for the transportation of limestone); radius of the concave curve R_2 = 100 m (the minimum permissible radius at belt width B = 800 mm); radius of the convex curve R_1 = 10 m (the minimum permissible radius at B = 800 mm and an angle of inclination of the side rollers λ = 30°); length of the horizontal section $l_{9\text{-}10}$ = 50 m; length of the horizontal projections of the sections $l_{r1\text{-}2} = l_{r7\text{-}8}$ = 1 m.

The lengths of the horizontal projections $l_{ri\text{-}j}$ and the lifting heights $h_{i\text{-}j}$ of the other sections are:

$$l_{r10\text{-}11} = l_{r5\text{-}6} = R_2.\sin\beta = 30.9 \text{ m} \quad (1)$$

$$h_{10\text{-}11} = h_{5\text{-}6} = R_2 - R_2.\cos\beta = 4.89 \text{ m} \quad (2)$$

$$l_{r12\text{-}13} = l_{r3\text{-}4} = R_1.\sin\beta = 3.09 \text{ m} \quad (3)$$

$$h_{12\text{-}13} = h_{3\text{-}4} = R_1 - R_1.\cos\beta = 0.48 \text{ m} \quad (4)$$

$$h_{11\text{-}12} = h_{4\text{-}5} = H - h_{10\text{-}11} - h_{12\text{-}13} = 18.63 \text{ m} \quad (5)$$

$$l_{r11\text{-}12} = l_{r4\text{-}5} = \frac{h_{11\text{-}12}}{tg\beta} = 57.34 \text{ m} \quad (6)$$

$$l_{13\text{-}14} = L_r - l_{r10\text{-}11} - l_{r11\text{-}12} - l_{r12\text{-}13} = 58.67 \text{ m} \quad (7)$$

$$l_{6\text{-}7} = l_{9\text{-}10} - l_{7\text{-}8} = 49 \text{ m} \quad (8)$$

$$l_{2\text{-}3} = l_{13\text{-}14} - l_{1\text{-}2} = 57.67 \text{ m} \quad (9)$$

The length of the conveyor is:

$$L = l_{9\text{-}10} + \frac{2.\pi.\beta.R_2}{360} + \frac{l_{r11\text{-}12}}{\cos\beta} + \frac{2.\pi.\beta.R_1}{360} + l_{13\text{-}14} = 203.5 \text{ m} \quad (10)$$

Short methodology of Promtransniiproekt

Required peripheral forces of the drive pulley at start-up and steady state working

$$P = k_\partial.k'_\partial.L_r.w.\left(q_м + q'_p + q''_p + 2.q_л\right) + q_м.H = 24370 \text{ N} \quad (11)$$

$$P_n = k_\partial.k'_\partial.L_r.w_n.\left(q_м + q'_p + q''_p + 2.q_л\right) + q_м.H = 26780 \text{ N}, \quad (12)$$

where: k_∂ - coefficient of the additional resistances from belt bending (it is chosen from Table 1 according to the conveyor length L; at $L \approx 200$ m $k_\partial = 1.45$);
k_∂' - correction coefficient (at horizontal conveyors and at inclined conveyors with length L < 100 m $k_\partial' = 1$; at inclined conveyors with length $L \geq 100$ m k_∂' is chosen from Table 2; at $L \approx 200$ m and $n = 5$ $k'_\partial = 1.15$);
w, w_n - coefficients of motional resistance during the belt movement at start-up and at steady state movement (at normal

conditions of exploitation they are assumed to be $w = 0.020$ and $w_n = 0.026$);
$q_м$ - linear gravity force of the material ($q_м$ = 681 N/m at conveyor capacity Q = 400 t/h and belt velocity v = 1,6 m/s);
$q_р'$, $q_р''$ [dN/m] - linear gravity forces of the rotating parts of the carry and return idlers (they are assumed to be $q_р'$ = 179 N/m and $q_р''$ = 64 N/m at belt width B = 800 mm, density of the material ρ = 1.5 t/m^3 and idler pitches $l'_р$ = 1 m и $l''_р$ = 2.2 m);
$q_л$ [dN/m] - linear gravity force of the belt (it is assumed to be $q_л$ = 140 dN/m at B = 800 mm).

Table 1. *Coefficient of additional resistances $k_д$*

L [m]	10	20	30	50	60	80	100
$k_д$	4.5	3.2	2.6	2.2	2.1	1.91	1.75

L [m]	120	140	160	180	**200**	250	300
$k_д$	1.7	1.6	1.55	1.5	**1.45**	1.38	1.32

L [m]	350	400	500	700	800	1000
$k_д$	1.28	1.24	1.19	1.12	1.095	1.087

Table.2. *Correction coefficient $k_д'$*

L [m]	100	150	**200**	300	500	≥ 800
n = 3 - **5**	1.04	1.13	**1.15**	1.3	1.42	1.53
n = 6 - 10	1.21	1.31	1.42	1.54	1.66	1.81

L - length of the conveyor; *n* - number of belt bending over the drive and non-drive pulleys and the convex sections of the conveyor. For the solved example (Fig.1) *n* = 5.

Belt tensions in the points of entering and leaving of the drive pulley at start-up and steady state working

$$S_{вл} = S_{14} = \frac{e^{\mu.\alpha}.P}{(e^{\mu\alpha} - 1)} = 33740 \text{ N} \quad (13)$$

$$S^n_{вл} = S^n_{14} = \frac{e^{\mu.\alpha}.P_n}{(e^{\mu\alpha} - 1)} = 37080 \text{ N} \quad (14)$$

$$S_{изл} = S_1 = S_{вл} - P = 9370 \text{ N} \quad (15)$$

$$S^n_{изл} = S^n_1 = S^n_{вл} - P_n = 10300 \text{ N} \quad (16)$$

where: μ - coefficient of friction between the belt and the drive pulley (it is assumed μ = 0.35 at rubber lagged pulley and dry surfaces);
α - wrap angle of the belt (α = 210° = 3.66 rad).

Required power on the shaft of the drive pulley

$$N_б = \frac{P.v}{1000} = 39 \text{ kW} \quad (17)$$

Precise methodology of Promtransniiproekt

Belt tensions

The belt tensions are determined using the method of going round of the contour. The resistances of the sections W_{i-j} are added consecutively to the belt tension in the point of leaving from the drive pulley $S_1 = S_{изл}$ and the remaining tensions are obtained. For the solved example for the start-up period it is obtained (according to the scheme of Fig.1):

$$S^n_1 = S^n_{изл} \quad (18)$$

$$S^n_2 = S^n_1 + W^n_{1\text{-}2} = S^n_1 + 0{,}02.S^n_1 \quad (19)$$

$$S^n_3 = S^n_2 + W^n_{2\text{-}3} = S^n_2 + \left(q_л + q''_р\right).w_n.l_{2\text{-}3} \quad (20)$$

$$S^n_4 = S^n_3 + W^n_{3\text{-}4} = S^n_3 + \left[S^n_3 + \left(q_л + q''_р\right).R_1\right].\beta.w_n \quad (21)$$

$$S^n_5 = S^n_4 + W^n_{4\text{-}5} = S^n_4 + \left(q_л + q''_р\right).w_n.l_{г4\text{-}5} - q_л.h_{4\text{-}5} \quad (22)$$

$$S^n_6 = S^n_5 + W^n_{5\text{-}6} = S^n_5 + \left(q_л + q''_р\right).w_n.l_{г5\text{-}6} - q_л.h_{5\text{-}6} \quad (23)$$

$$S^n_7 = S^n_6 + W^n_{6\text{-}7} = S^n_6 + \left(q_л + q''_р\right).w_n.l_{6\text{-}7} \quad (24)$$

$$S^n_8 = S^n_7 + W^n_{7\text{-}8} = S^n_7 + 0{,}02.S^n_7 \quad (25)$$

$$S^n_9 = S^n_8 + W^n_{8\text{-}9} = S^n_8 + 0{,}04.S^n_8 \quad (26)$$

$$S^n_{10} = S^n_9 + W^n_{9\text{-}10} = S^n_9 + \left(q_м + q_л + q'_р\right).w_n.l_{9\text{-}10} \quad (27)$$

$$S^n_{11} = S^n_{10} + W^n_{10\text{-}11} = S^n_{10} + \left(q_м + q_л + q'_р\right).w_n.l_{г10\text{-}11} + \\ + \left(q_м + q_л\right).h_{10\text{-}11} \quad (28)$$

$$S^n_{12} = S^n_{11} + W^n_{11\text{-}12} = S^n_{12} + \left(q_м + q_л + q'_р\right).w_n.l_{г11\text{-}12} \quad (29)$$

$$S^n_{13} = S^n_{12} + W^n_{12\text{-}13} = S^n_{12} + \left[S^n_{12} + \left(q_м + q_л + q'_р\right).R_1\right].\beta.w_n \quad (30)$$

$$S^n_{14} = S^n_{вл} = S^n_{13} + W^n_{13\text{-}14} = S^n_{13} + \left(q_м + q_л + q'_р\right).w_n.l_{13\text{-}14} \\ = 1{,}097.S^n_1 + 22231 \quad (31)$$

On the other hand:

$$S^n_{14} = S^n_1.e^{\mu.\alpha} = 3.61.S^n_1 \quad (32)$$

When the equations (31) and (32) are solved together, the tension S_{1n} is obtained:

$$1.097.S^n_1 + 22331 = 3.61.S^n_1 \quad (33)$$

$$S^n_1 = 8870 \text{ N} \quad (34)$$

Using the formulae (19)÷(31) the remaining tensions are obtained. The tensions at steady state of working are obtained by analogy, but the coefficient of motional resistance is taken w = 0.020 instead of w_n = 0.026. The results from the calculations of the belt tensions at start-up and at steady state working are given in Table 3.

Table 3. *The results from the calculations of the belt tensions at start-up and at steady state working*

Formula for calculation (w_n=0.026)	Belt tensions [N]	
	Start-up w_n=0.026	Steady state w = 0.020
S_1^n = 8870	S_1^n = 8870	$S_1 = S_{изл}$=8250
S_2^n = 1.02. S_1^n	S_2^n = 9050	S_2 = 8420
S_3^n = 1.02. S_1^n + 306	S_3^n = 9350	S_3 = 8660
S_4^n = 1.036. S_1^n +358	S_4^n = 9370	S_4 = 8650
S_5^n = 1.036. S_1^n - 2048	S_5^n = 7070	S_5 = 6280
S_6^n = 1.036. S_1^n - 2567	S_6^n = 6550	S_6 = 5720
S_7^n = 1.036. S_1^n - 2307	S_7^n = 6810	S_7 = 5920
S_8^n = 1.056. S_1^n - 2354	S_8^n = 6940	S_8 = 6030
S_9^n = 1.098. S_1^n - 2448	S_9^n = 7210	S_9 = 6270
S_{10}^n = 1.98. S_1^n + 1148	S_{10}^n = 8510	S_{10} = 7270
S_{11}^n = 1.098. S_1^n + 3662	S_{11}^n =13320	S_{11} = 11890
S_{12}^n = 1.098. S_1^n + 20457	S_{12}^n =30110	S_{12} = 28340
S_{13}^n = 1.11. S_1^n + 20706	S_{13}^n =30430	S_{13} = 28580
S_{14}^n = 1.11. S_1^n + 22231	S_{14}^n =31960	$S_{14} = S_{вл}$= 29750

Required peripheral force on the drive pulley

$$P = \frac{S_{вл} - S_{изл}}{\eta_б} = 23120 \text{ N} \quad (35)$$

where: $\eta_б$ - coefficient of efficiency of the drive pulley (it is determined by formula (36))

$$\eta_б = \frac{1}{1+w_б.\left(2.\frac{e^{\mu.\alpha}}{e^{\mu\alpha}-1}-1\right)} = 0.93 \quad (36)$$

where: $w_б$ - coefficient of resistance of the drive pulley taking an account of the belt bending (it is assumed to be $w_б$=0.04).

Required power on the shaft of the drive pulley

$$N_б = \frac{P.v}{1000} = 37 \text{ kW} \quad (37)$$

Short methodology according to the standard DIN 22101

Required drive power

$$P_T = P_1 + P_2 + P_3 = 35.8 \text{ kW} \quad (38)$$

where: P_1 [kW] - required power for the belt and the material moving on the rollers (it is determined by formula (39));
P_2 [kW] - required power for the material lifting (it is determined by formula (40));
P_3 [kW] - sum of the required additional powers for the trippers, side boards and unloading ploughs (when there are no trippers boards and ploughs P_3=0);

$$P_1 = \frac{c_B.v + Q_m}{c_L.k_f} = 9.7 \text{ kW} \quad (39)$$

$$P_2 = \frac{H.Q_m}{367} = 26.1 \text{ kW} \quad (40)$$

where: c_B - coefficient depending on the belt width and the density of the transported material (it is determined by Table 4; at B = 800 mm and ρ = 1.5 t/m^3 it is assumed c_B = 126);
c_L - coefficient depending on the conveyor length (it is determined by Table 5; at L = 203,5 m after interpolation it is assumed c_L = 62);
k_f - coefficient depending on the working conditions (it is determined by Table 6; at medium (normal) working conditions k_f = 1).

Table 4. *Coefficient c_B depending on the belt width*

ρ [t/m^3]	Belt width B [mm]					
	650	**800**	1000	1200	1400	1600
< 1	81	108	133	194	227	291
1-2	92	**126**	187	277	320	468
> 2	103	144	241	360	414	644

ρ - density of the material

Table 5. *Coefficient c_L depending on the conveyor length*

L [m]	10	20	32	50	80	100	150	**200**
c_L	417	286	222	167	119	103	77	**63**

100	150	200	250	300	500	800	1000	2000
103	77	63	53	47	31	20	17	9

Table 6. *Coefficient k_f depending on the working conditions of the conveyor*

Working conditions	k_f
Light Good belt centering, small belt velocity	1.17
Medium (normal, standard)	**1**
Heavy Dusty atmosphere, low temperatures, overloading, high belt velocity	0.87 – 0.74

Precise methodology according to the standard DIN 22101

Belt tensions at steady state working

According to the scheme of Fig.1 the correspondence of the belt tensions is: T_2 to S_1, T_3 to S_8, T_4 to S_9 и T_1 to S_{14}.

$$T_2 = F_U.c_2 = 8910 \text{ N} \quad (41)$$

$$T_3 = T_2 + F_u - F_{Stu} = 6330 \text{ N} \quad (42)$$

$$T_4 = T_3 \,; \qquad T_1 = T_4 + F_N + F_o + F_{Sto} = 32070 \text{ N} \quad (43)$$

where: F_U - total peripheral force on the drive pulley (it is determined by formula (44));
c_2 - drive factor for the determination of the belt tension in point of leaving from the drive pulley (it is determined by formula (45));
F_o, F_u - primary resistances in the carry and the return run (from the belt and material movement, rotation of the rollers, bending of the belt, strike of the belt to the rollers, inner friction of material etc. (they are determined by the formulae (46) and (47));

F_{Stu}, F_{Sto} - gradient resistances in the carry and the run side (they are determined by the formulae (48) and (49));
F_N - total secondary resistance (from the bending of the belt around the pulleys, friction in the pulley bearings, resistances in the loading and cleaning devices, etc. (it is determined by the formula (50)).

$$F_U = F_H + F_N + F_{St} = 23170 \text{ N} \quad (44)$$

$$c_2 = \frac{1}{e^{\mu.\alpha} - 1} = 0.3846 \quad (45)$$

$$F_o = f.L.g.\left[m'_{Ro} + \left(m'_G + m'_L\right).cos\delta\right] = 3910 \text{ N} \quad (46)$$

$$F_u = f.L.g.\left(m'_{Ru} + m'_G\right).cos\delta = 790 \text{ N} \quad (47)$$

$$F_{Sto} = H.g.\left(m'_G + m'_L\right) = 19710 \text{ N} \quad (48)$$

$$F_{Stu} = H.g.m'_G = 3370 \text{ N} \quad (49)$$

$$F_N = (C - 1).F_H = 2120 \text{ N} \quad (50)$$

where: f - coefficient of motional (primary) resistance (it is assumed $f = w = 0.02$);
m'_{Ro}, m'_{Ru} - linear masses of the rotating parts of the idlers in the carry and the return run (they are assumed according to the previously chosen $q'_p = 179$ N/m and $q''_p = 64$ N/m - $m'_{Ro} = 18.3$ kg/m and $m'_{Ru} = 6.5$ kg/m);
m'_G, m'_L - linear masses of the belt and the material (they are assumed according to the previously chosen $q_л = 140$ N/m and $q_м = 681$ N/m - $m'_G = 14.3$ kg/m and $m'_L = 69.4$ kg/m);
δ - angle of inclination of the conveyor ($\delta = \beta = 18°$);
C - coefficient of secondary resistance (corresponds to the coefficient $k_д$; it is assumed $C = k_д = 1.45$ from Table 1);
F_H - total primary resistance (it is determined by the formula (51));
F_{St} - total gradient resistance (it is determined by the formula (52)).

$$F_H = f.L.g.\left[m'_{Ro} + m'_{Ru} + \left(2.m'_G + m'_L\right).cos\delta\right] = 4710 \text{ N} \quad (51)$$

$$F_{St} = H.g.m'_L = 16340 \text{ N} \quad (52)$$

Belt tensions at start-up

$$T_{A2} = F_A.c_{2A} = 10590 \text{ N} \quad (53)$$

$$T_{A3} = T_{A2} + F_u - F_{Stu} + F_{au} = 10020 \text{ N} \quad (54)$$

$$T_{A4} = T_{A3} = 10020 \text{ N} \quad (55)$$

$$T_{A1} = T_{A4} + F_N + F_o + F_{Sto} + F_{ao} = 45750 \text{ N} \quad (56)$$

where: c_{2A} - drive factor at start-up (it is determined by the formula (57));
F_{au}, F_{ao} - acceleration forces in the carry and return run (they are determined by the formulae (58) and (59));

$$c_{2A} = \frac{1}{e^{\mu_A.\alpha} - 1} = 0.3009 \quad (57)$$

$$F_{ao} = L.a_A.\left(0.9.m'_{Ro} + m'_G + m'_L\right) = 9990 \text{ N} \quad (58)$$

$$F_{au} = L.a_A.\left(0.9.m'_{Ru} + m'_G\right) = 2010 \text{ N} \quad (59)$$

where: μ_A - coefficient of friction between the belt and the pulley at start-up (it is determined by the formula (60));
a_A - acceleration of the conveyor at start-up (it is determined by the formula (61));

$$\mu_A = \mu + 0.05 = 0.4 \quad (60)$$

$$a_A = \frac{F_A - F_U}{L.\left(0.9.m'_{Ro} + 0.9.m'_{Ru} + 2.m'_G + m'_L\right)} = 0.49 \text{ m/s}^2 \quad (61)$$

where: F_A - peripheral force on the drive pulley at start-up (it is determined by the formula (62)).

$$F_A = k_A.F_U = (1.2 \div 1.5).F_U = 1.3.F_U = 35200 \text{ N} \quad (62)$$

Correction of the belt tensions at the steady state working according to the kind of the tension device

A condition is used that the belt tensions in the point, where the tension weight is put (in this case on the return pulley), at start-up and steady state working are equal. This means that $T_{A4} = T_4$. Then for the belt tensions at steady state working after the correction with the value of $\Delta T = T_{A4} - T_4$ it is finally obtained:

$$T_{A4} = T_4; \quad \Delta T = T_{A4} - T_4 = 3690 \text{ N} \quad (63)$$

$$T_1 = T_1 + \Delta T = 35760 \text{ N} \quad (64)$$

$$T_2 = T_2 + \Delta T = 12600 \text{ N} \quad (65)$$

$$T_3 = T_4 = T_3 + \Delta T = 10020 \text{ N} \quad (66)$$

Required drive power

$$P_T = \frac{F_U.v}{1000} = 37 \text{ kW} \quad (67)$$

Conclusions

The results of the calculations are generalised in Table 7.

Table 7. *Comparative results of the calculations of the belt tensions and the required drive power*

Methodology	1	2	3	4
T_1 (S_{14}, $S_{вл}$) [N]	33740	29750	-	35760
T_2 (S_1, $S_{изл}$) [N]	9370	8250	-	12600
T_3 (S_8) [N]	-	6030	-	10020
T_4 (S_9) [N]	-	6270	-	10020
T_{A1} (S_{14}^n) [N]	37080	31960	-	45750
T_{A2} (S_1^n) [N]	10300	8870	-	10590
T_{A3} (S_8^n) [N]	-	6940	-	10020
T_{A4} (S_9^n) [N]	-	7210	-	10020
P_T ($N_б$) [kW]	39	37	35,8	37

1 - Promtransniiproekt short; 2 - Promtransniiproekt precise;
3 - DIN 22101 short; 4 - DIN 22101 precise.

The following conclusions can be drawn from the calculations using the four discussed methodologies:

1. Approximately equal values are obtained for the required drive power P_T ($N_б$). The highest is the value obtained by methodology 1 and the smallest - by methodology 3.

2. a Smaller values are obtained for the belt tensions according to the precise methodology (methodology 2) in comparison with the short methodology (methodology 1).

3. Higher values are obtained for the belt tensions using the precise methodologies (2 and 4) according to methodology 4 in comparison with methodology 2. The reason is the difference in the methods for their determination. In methodology 2 the belt tensions at start-up are determined in the same way as at steady state working, but a higher coefficient of motional resistance is assumed. In methodology 4 the acceleration forces at start-up are considered.

4. Higher values are obtained for the belt tensions at steady state working using the precise methodologies in methodology 4. The reason is the correction (increase) of the tensions in accordance with the condition, that in the point where the tension weight is put the tensions at start-up and steady state working are equal.

5. The calculations are accomplished at equal coefficients of motional (primary) resistance f (w). It should be noticed, that in methodologies 1 and 2 it is recommended to take higher coefficients of motional in comparison with methodologies 3 and 4. This will lead to the increase of the belt tensions, determined by methodologies 1 and 2.

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