CONSTRUCTIVE DESIGN OF A BELT CONVEYOR FOR A COAL MINE

M.Sc. Solak A.[1], M.Sc. Kalay E. [1], Prof. Dr. Imrak E.[2]
Faculty of Mechanical Engineering – Yildiz Technical University, Turkey [1]
Faculty of Mechanical Engineering – Istanbul Technical University, Turkey [1]
Faculty of Mechanical Engineering – Istanbul Technical University, Turkey [2]

asolak@yildiz.edu.tr, kalaye@itu.edu.tr , imrak@itu.edu.tr

Abstract: *At the present time, mines, power plants, ports are more complicated and more functional compared to the past therefore raw material processing, production, and amount of transportation material have increased. In this paper it is calculated with using necessary equations with standard charts that a stone cargo construction with 500 t/h in the line which is formed by two conveyors with 500 m straight and 100 m which has 30^o slope.*

Keywords: BELT CONVEYOR, CONSTRUCTIVE DESIGN, TRANSPORTATION,

1. Introduction

Transportation means movement of people or goods from one place to another with consuming minimum energy in shortest way. Belt conveyors are a kind of transportation system that serves for this purpose. Handling with natural conditions is another important property of belt conveyors also. It can be settled down easily through the mountains and over the rivers. While it is so difficult carrying stuff in inclined places with truck or rig, easy with belt conveyors at the same conditions.

Fig 1 *Belt conveyor*[1]

Beside carrying goods in shortest way, belt conveyors also save up time, labor cost and economy. If tons of material will be transported through complex ways, belt conveyors are an exact solution cause of its continuity. In this paper it is aimed to calculate the constructive properties of belt conveyor that has 500 m length straight and 100 m that inclined 30. Weight of the parts, engine power, friction forces and bent forces are some of the calculated constructive properties of the conveyor. After specifying the characteristics of the conveyor, the values of engine power and bent forces are showed on the graphic according to the changing slope of the belt conveyor first, and then same values are showed on the other graphic according to the changing angle between tambours.

2. Inclined Belt Conveyor

At this section calculation will be done for only inclined part of the belt conveyor. The length of the belt conveyor is 100 m and it has 30^o slope. Designing parameter could change according to the heap material mostly cause of the pile angle. The heap material for the conveyor is coal, so some properties of the coal are given in Table 1.

Table 1*: Some mechanical properties of coal*[2]

Pile mater.	Density of coal [t/m^3]	Maximum slope	Pile angle Static	Slope Resistance Coefficient	Particle Size a [mm]
Coal	0,9	15	40	1,85	80

Transportation capacity of the belt conveyor is 500 tons per hour and velocity is 1,75 meter per second and also specific weight of the heap has given 0,9 t/m^3. According to these values from Table 2, bent width can be chosen 2 meters.

Table 2*: Weight of the pile*[2] *[daN/m]*

Bent width [mm]	Specific weight of the pile [t/m^3]		
	0,45-1,20	1,2-2,00	2,00-3,00
1000	15,0	16,0	19,2
1400	22,5	25,5	29,2
1600	27,6	30,3	33,5
1800	30,0	35,0	38,0
2000	33,0	40,0	42,0

Belt conveyor can consist of two parts that are tail pulley and carrying pulley. In order to increase stability tension pulley can be added to the system. As it seen in the Fig. 2.1, the number of tension pulley can be one or two. In this project two tension pulley is used. The angle between tension pulley and ben gives as the deflection angle that mentioned forward again to see the power changing related to the this angle.

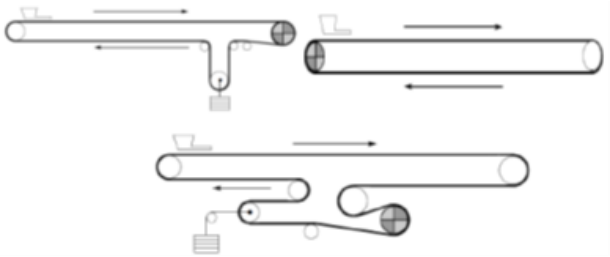

Fig 2 *Belt conveyor with tension pulley*[1]

Bent width is one of the major parameter at design step. The other values are shaped according to bent width. The next step is specifying the distance between tail pulley and carrying roller. After deciding the bent width, the distance can be chosen from Table 3 as 1000 mm and 2500 mm corresponding to L_T and L_D.

Table 3: *Distance between tail pulley and carrying roller*[2]

Bent width [mm]	L_T [mm] Specific weight of the material [t/m^3]						Tail Pulley L_D
	0,5	0,8	1,2	1,6	2,0		
1000	1400	1400	1200	1000	1000	900	2700
1200	1200	1200	1000	1000	900	900	2700
1400	1200	1200	1000	1000	900	900	2700
1600	1200	1000	1000	900	900	900	2500

2000	1200	1000	1000	900	900	900	2500

Rough sketch is showed up after specifying the distance and bent width of the conveyor. In order to calculate the power specific weights are needed. Specific weight of the movable parts of the belt conveyor can be calculated from the equation (2.1).

$$G_1 = 2G_B + \frac{G_T}{L_T} + \frac{G_D}{L_D} \quad (2.1)$$

The values G_T and G_D are given in Table 4 and the value of G_B can be reached from Table 2.

Table 4: *Tail pulley and dual group*[2]

Bent width B [mm]	Pulley Dia D [mm]	Triad L	Triad G_T	Dual Group L	Dual Group G_T	Tail Pulley L	Tail Pulley G_T
500	89 108	200 200	7,5 9,8	315 315	7,2 9,2	600 600	6,4 7,8
650	108 133	250 250	9,0 11,4	- -	- -	750 750	8,0 9,6
800	108 133	315 315	13,8 18,6	- -	- -	750 950	12,7 12,0
1000	133 133	315 380	18,6 21,6	- -	- -	950 1150	16,0 19,0
1200	133	465	25,4	-	-	1400	23,0
1400	133	530	28,3	-	-	1600	26,0

It has given the length of the inclined conveyor is 100 m. But in calculation it is preferred to use the equivalent length rather than its own length. Equivalent length can be find from the equation 2.2.

$$L_{eş} = L + 45 \quad (2.2)$$

The main dimensional parameters are cleared until now. Next step is determining the engine power. Engine power is total value of the required power for horizontal transport, vertical transport, without pile etc. First, required power for the transporting with no pile will be calculated as is given in equation 2.3. The value of the f_1 can be taken between 0,015 and 0,04, it is taken 0,03 for this situation.

$$P_1 = \frac{f_1 G_1 L_{eş} v}{75} \quad (2.3)$$

Required power to transport horizontally is as given below. The point to be emphasized is that despite calculation are done for horizontal transportation the length of the conveyor is still equivalent length of the conveyor belt.

$$P_2 = \frac{f_1 L_{eş} Q}{270} \quad (2.4)$$

Required power to transport vertically is can be calculated with the equation 2.5.

$$P_3 = \pm \frac{QH}{270} [hp] \quad (2.5)$$

In calculation, flow rate has to be divided to the capacity reducing factor as is shown in Table 5.

Table 5*: Capacity reducing factor related to the slope*[2]

Slope of the conveyor belt φ	k
8°	0,96
12°	0,93
16°	0,87
20°	0,79
24°	0,71
26°	0,66
30°	0,56

Required power for dumper car can be identified by using Table 6 instead of calculating. As it seen below, it should be iterated to determine the value. It has been chosen 9,41 horse power after iterating.

Table 6: *Power for dumper car*[2]

Bent width [mm]	800	1000	1200	1400	1600
Required power [hp]	2,5	3,5	5,0	6,0	8,0

Total power is;

$$P = P_1 + P_2 + P_3 + P_4 + P_5 \ [HP] \quad (2.6)$$

The value of P_5 corresponds to acceleration power but it is neglected generally and so, it has been neglected for this situation also.

Engine power should be over the total power because of that power loss occurs while transferring the engine power to the shaft and also in order to ease first movement of the engine power should be increased in proportion to between 1.1 and 1.4.

$$P_m = (1.1 \div 1.4)\frac{P}{\eta} \quad (2.7)$$

Table 7: *The power of the engine*[2]

	Power [hp]
P_1	10,92
P_2	14,38
P_3	165,34
P_4	9,41
P_5	-
Total power	200,6
Engine power	287,004

After determining the powers, friction forces of the tail pulley and jockey pulley will be calculated. First, friction force of the tail pulley is calculated as is given below.

$$T_D = \mu_1 \left(G_B + \frac{G_D}{L_D} \right) L_{eş} [N] \quad (2.8)$$

We can choose μ_1 as 0,025[3] and then the tension pulley

$$T_T = \mu_2\left(G_B + \frac{G_T}{L_T} + \frac{Q}{3.6\,V}\right) L_{eş}[N] \quad (2.9)$$

After obtaining the friction force values of the tension pulley and tail pulley the belt forces are can be calculated with the given equations.

$$P = \frac{T_E\, v}{75} \quad (2.10)$$

The deflection angle can be taken[4] between 260-270^0, in this problem it has taken 265^0 and the value of μ has taken as 0,3.

$$\frac{T_1}{T_2} = e^{\mu\alpha} \quad (2.11)$$

T_E corresponds to the difference between T_1 and T_2. From equation (2.12) tensed bent force can be found. The relationship between the bent forces T_1 and T_2 can be found from equation (2.11).

$$T_1 = \left(\frac{75Pe^{\mu\alpha}}{v(e^{\mu\alpha} - 1)}\right) \quad (2.12)$$

***Table 8**: The bent forces*

	Bent Forces [daN]
T_1	16390
T_2	4090

3. Conclusion

The result of these calculated values are for only 30^o which is the slope of the bent conveyor. If we want to see the results for the angles between 0^o and 30^o it can be shown graphically.

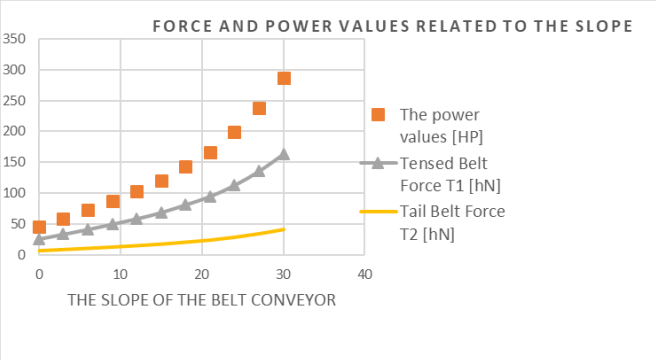

***Fig 3** Force and power values related to the slope*

The horizontal line on the axis shows the slope of the belt conveyor and the vertical one is the the value of the forces and power of the conveyor. First, it can be seen that increasing value of the slope leads to the increasing power and the belt forces and also it can be claimed that required power and the belt forces increasing exponantially. In order to avoid high costs and catastrophic failures the slope of the belt conveyor should be kept lower.

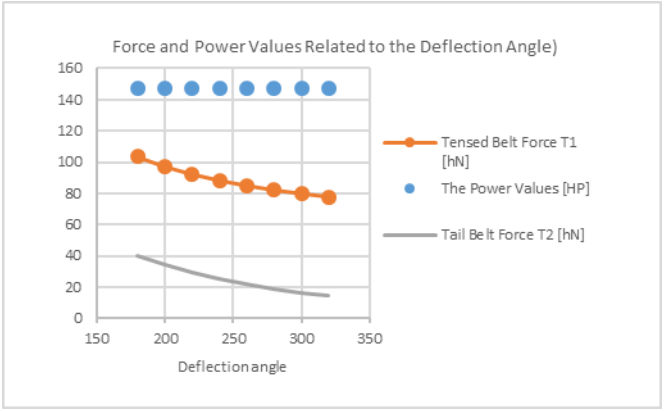

***Fig 4** Force and power values related to the deflection angle*

In figure 3.2 it is shown that the relationship between results and deflection angle. As it is seen, deflection angle has no effect on the power but the forces on the belt decrease. Increasing value of the deflection angle has positive effect because stress value decreases as the force decreases on the belt.

REFERENCES

[1] Gerdemeli, I. & Imrak C. E. & Kesikci M. K. (2005). Continuous Transport Systems. (Lecture Book). Istanbul, Publisher of Birsen.

[2] Lucas, J. D. (2008). Improving conveyor belt safety training through the use of virtual reality. (Master Thesis). State University, Virginia Polytechnic Institute, Virginia.

[3] Erkayaoglu, M. (2011). Life cycle assessment of off-highway trucks and belt conveyors for sustainable mining. (Master Thesis). Middle East Technical University, Institute of Science, Ankara.

[4] Solak, A. (2016). Belt conveyor design for coal minerals and optimization of design parameters. (Master Thesis). Istanbul Technical University, Institute of Science, Istanbul.