International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 3 Issue 5, August 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Analysis of Belt Bucket Elevator

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How to cite this paper: Mg Than Zaw Oo | Ma Myat Win Khaing | Ma Yi Yi Khin "Analysis of Belt Bucket Elevator" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-5, August 2019, pp.760-763, **https://doi.org/10.31142/ijtsrd26483**

IJTSRD26483

ABSTRACT

This paper describes the analysis of belt bucket elevator used in Myanmar C.P Livestock Co.Ltd (Taunggyi feed mill). Material handling process is essential for the production. Bucket elevator has evolved as advanced material handling equipment in the mechanized bulk material handling industry. The effective use of different types of bucket elevators completely depends on its design and types of bulk material. Yellow corn raw materials are transported by bucket elevator. In this journal, the use of conveyor systems and the design of bucket elevator with simultaneous buckets for lifting yellow corn at 28.8 m height are presented. And it is 70 tons per hour. The main aim is to share about conveyor systems and to know the calculation of belt design, shaft and pulley.

KEYWORDS: *Belt Bucket, Conveyor, Elevator, Pulley, Shaft*

I. INTRODUCTION

Conveyors are one subset of a larger group of material handling equipment. The major objectives implementing conveyors is to reduce manual handling, ease the workload of the operator, accelerate workflow between operations, increase throughput, etc. Conveyors are classified into several types according to application. Some types include belt conveyor, chain conveyor, bucket elevator and gravity conveyor. In this paper, the yellow corn drying process consists of intake receiving and cleaning line, dryer and temporary silo line and storage silo and load out pin line. Corns are classified into two groups, grade-2 and S-3.

Laid corns were carried to the screener by a chain conveyor and bucket elevator. Then rubbish and piece of iron are cleaned by screener and dust were absorbed by a blower. After cleaning, corns were sent to four temporary silos (each silo 250 tons), before sending to second cleaning tower. The second cleaning tower is the same as the first cleaning tower except for drum sieve.

II. Types of Conveyor

A convenient classification of some of the more important conveyors is as follows:

- Chain conveyors
- Screw conveyors
- Belt conveyors
- Bucket elevators

The choice of conveyor depends largely upon the specified capacity, conveying distance and configuration (whether horizontal, vertical or inclined), bulk solids and individual particle properties and temperature. Generally, bucket elevators are classified in mainly two types. They are:

- Belt type bucket elevator
- Chain type bucket elevator

III. Components of Belt Bucket Elevator

The detail description of various parts of bucket elevators , below. The major components of belt bucket elevator are: Drive headcover, Drive unit, Outlet, Casing, Inspection section, Pulley take-up, Bottom head, Inlet and Buckets.

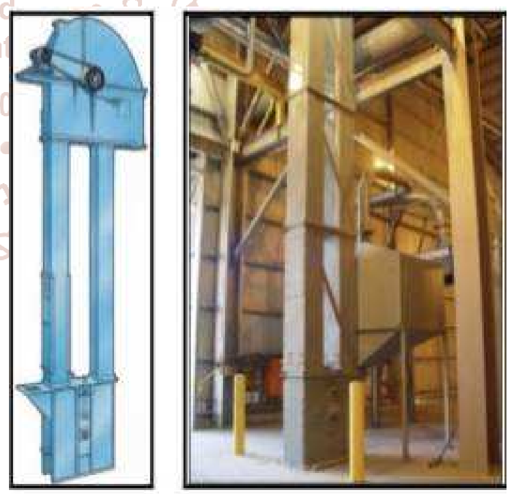

Figure1. Belt Bucket Elevator

V type plastic buckets are used in bucket elevators at yellow corn drying process Myanmar C.P Livestock Co. Ltd (Taunggyi feed mill). The belt is used to transmit power from one shaft to another by mean of pulleys which rotate at the same speed. The belt is jointed with a bucket by a nut to lift product from one place to another. There are many types of belt. Flat belt type is used for bucket elevators. The material is used for belt must be strong, flexible, and durable. It must have a high coefficient of friction. Leather belts are used in the yellow corn drying process of bucket elevators. Belt and buckets are shown in Figure 2.

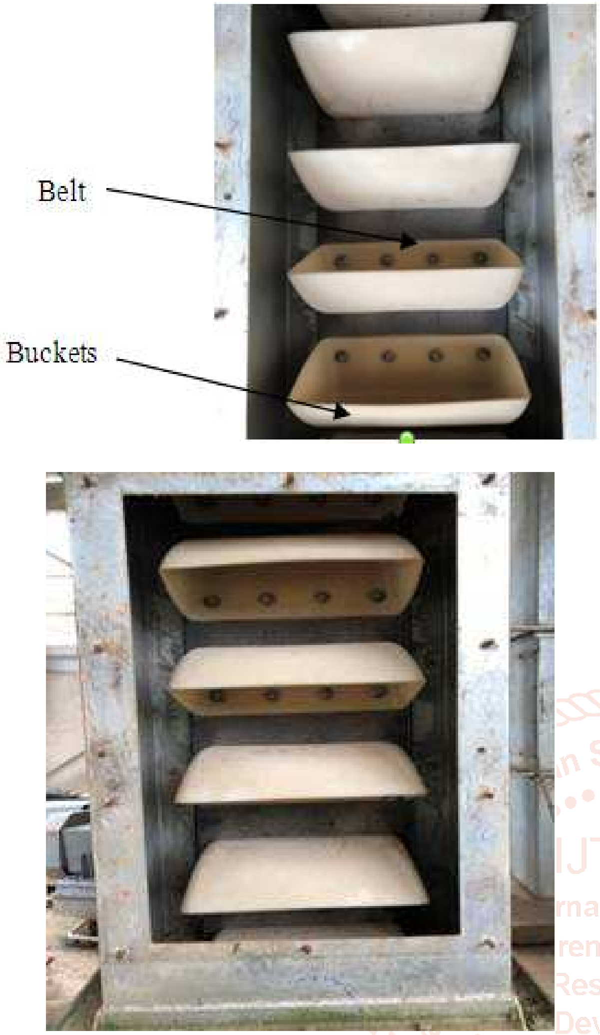

Figure2. Belt and Buckets

IV. Operation of Belt Bucket Elevator

Bucket elevators operate by using an endless belt on which rectangular buckets are mounted. The belt revolves between a top and bottom pulley and the buckets move with it. At the bottom, the bucket picks up yellow corns into the elevator boot and at the top the yellow corns are discharged as the bucket turns downward over the head pulley. The bucket elevator is normally designed and made for metallurgy, chemical industry, building materials, mine, pulp and paper industries, ports and terminal, grain and vegetable oil, food, fodder, plastic and medicine related application.

V. Design Theory

Working Stresses in Belts,

$$\sigma = \frac{T_1}{bt} \qquad 1$$

Where, σ = Stress of belt
T_1 = Tension in right side
B = Width of belt t = Thickness of belt

Length of Open Belt Drive,
An open belt drive is used to rotate the driven pulley in the same direction of driving pulley. The length of belt can be calculate by the following equation, Open belt drive is shown in Figure 3.

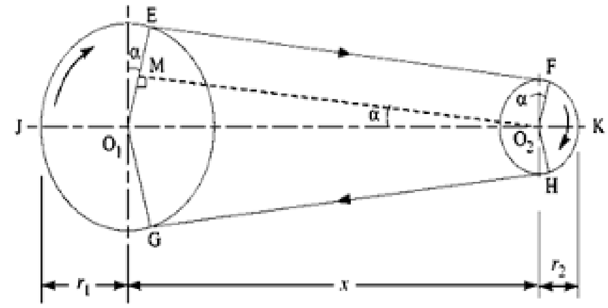

Figure3. Open Belt Drive

$$L = \pi(r_1+r_2)+2x+\frac{(r_1 - r_2)^2}{x} \qquad 2$$

Where r_1 and r_2 =Radii of the larger and smaller pulleys
x = Distance between the centers of two pulleys
L =Total length of the belt

Maximum Tension in the Belt

The maximum tension in the belt is equal to the total tension on the right side of the belt.

T= Maximum stress × Cross section area of the belt
$$T= \sigma \times b \times t \qquad 3$$

When, Centrifugal tension is considered,
$$T = T_1+T_C \qquad 4$$

Where σ=Maximum safe stress
B =Width of the belt
t =Thickness of the belt
T_1 =Tension in the tight side
T = Maximum tension in the belt
Centrifugal Tension,

The tension caused by the centrifugal force is called centrifugal tension.
$$F_C = mv^2 \qquad 5$$

Where, F_C=Centrifugal tension
M = Mass of belt per unit length in kg
V = Linear velocity of belt in m/s
Ratio of Driving Tension for Flat Belt Drive,

$$\frac{T_1}{T_2} = e^{\mu\theta} \qquad 6$$

Where, T_1=Tension in the tight side
T_2 =Tension in the slack side
μ = Coefficient of friction between belt and pulley θ=Angle of contact
Power Transmitted by a Belt

Power transmitted between a belt and a pulley is expressed as the product of difference of tension and belt velocity.
$$P = (T_1 - T_2)\, v \qquad 7$$

Where, P=Power transmitted by the belt
T_1 = Tension in the tight side
T_2 = Tension in the slack side
V = Velocity of the belt in m/s
Power,

Electrical power is the rate at which electrical energy is converted to another form, such as motion, heat, or an electromagnetic field. The common symbol for power is the uppercase letter P, the standard unit is the WATT, symbolized by W.

$$P=\frac{2\pi \times N \times T}{60} \quad 8$$

$$T=F \times r \quad 9$$

$$N=\frac{v \times 60}{\pi d} \quad 10$$

Where, P=Power (kW)
N = Drive pulley rpm
T = Torque (Nm)
R = Pulley radius (m)
v = Velocity of belt (m/s)
d = Pulley diameter (m)

Relationship between Centripetal Force and Gravity force,

$$F_C = \frac{mv^2}{r} \quad 11$$

$$F_g = mg \quad 12$$

Where, F_C = Centripetal force
F_g = Gravity force
M = Material mass in the bucket
v = belt velocity in m/s
g = Gravity acceleration, 9.81 m/s²
Equivalent Bending Moment Theory,

The equivalent bending moment may be defined as the bending moment which will produce by the bending moment and torque acting separately.

$$M_e = \frac{1}{2}(M+\sqrt{M^2+T^2}) \quad 13$$

$$\sigma = \frac{32M_e}{\pi d^3} \quad 14$$

$$\sigma = \frac{\text{Ultimate tensile stress}}{\text{factor of safety}} \quad 15$$

Where, M_e=Equivalent bending moment
M = Maximum bending moment
T = Torque to be transmitted by the shaft
σ = Allowable tensile stress
D = Diameter of shaft

Equivalent Twisting Moment Theory,
The equivalent twisting moment may be defined as the torque which will produce the same maximum shear stress as produced by the bending moment and torque acting separately.

$$T_e = \sqrt{M^2+T^2} \quad 16$$

$$T = \frac{16T_e}{\pi d^3} \quad 17$$

$$\tau = \frac{\text{Ultimate shear stress}}{\text{factor of safety}} \quad 18$$

Where, T_e=Equivalent twisting moment
M = Maximum bending moment
T = Torque to be transmitted by shaft
τ = Allowable shear stress
d = Diameter of shaft

$$\text{Area of pulley, } A=\frac{\pi}{4}\times(D^2-d^2) \quad 19$$

Volume of pulley, V = A×L
Mass of pulley, m = ρ × V
Weight of pulley, W_p= mg

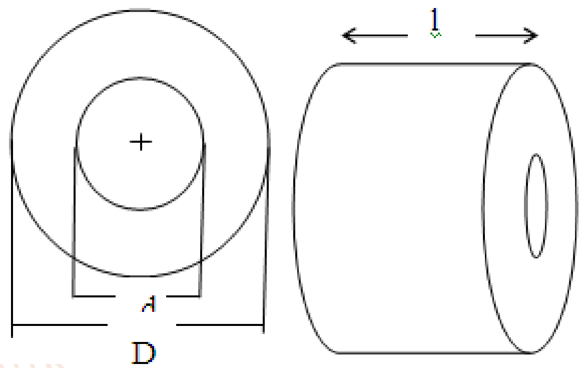

Figure4. Pulley

Material of pulley = Gray cast iron
Density of gray cast iron, ρ = 7200 kg/m³
Outside diameter, D = 60 cm
Inside diameter, d = 53cm
Length of belt, L = 40 cm
Weight of Empty Buckets,
Number of buckets = 350 buckets
Mass of each buckets = 0.75 kg

$$W_{eb} = m \times \text{no; of buckets} \times g \quad 20$$

Weight of Corn Weighting in the Bucket Elevator,
Weight of corn weighing in one revolution =175 buckets
Mass of corn per bucket= 1.7 kg

$$W_c= m \times \text{no; of buckets} \times g \quad 21$$

Applied Force,
Force acting on the shaft is the sum of all rotation component weight,

$$F = W_b + W_p + W_{eb} + W_c \quad 22$$

VI. Result for Bucket Elevator

Design Data,
Capacity = 70 tons per hour
Lifting height = 28.8 m
Material for lifting = yellow corn
Density of corn, ρ = 720 kg/m³
Bucket spacing = 6buckets/m
Specific gravity, g = 9.81 m/s²
Bucket length, L = 28.6 cm
Bucket width, b = 11.3 cm

Application: To transfer large amount of yellow corn from ground floor to required destination.

The capacity of Bucket,

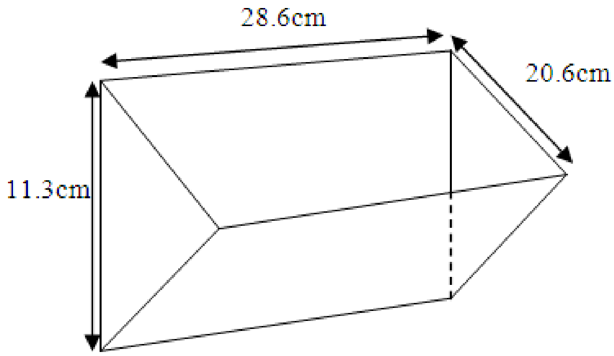

Figure5. Size of Bucket

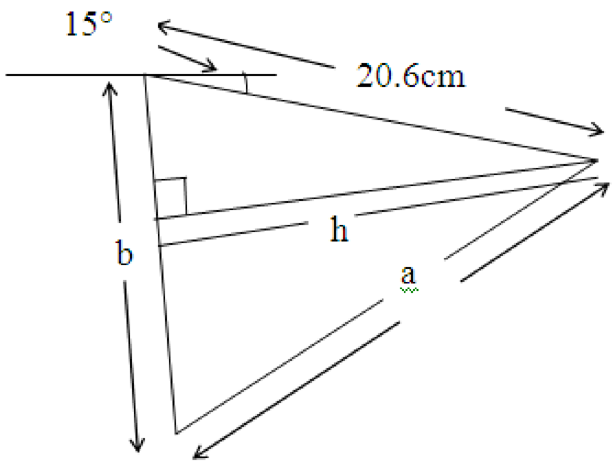

Figure6. Cross Section View of Bucket

Weight of Belt,

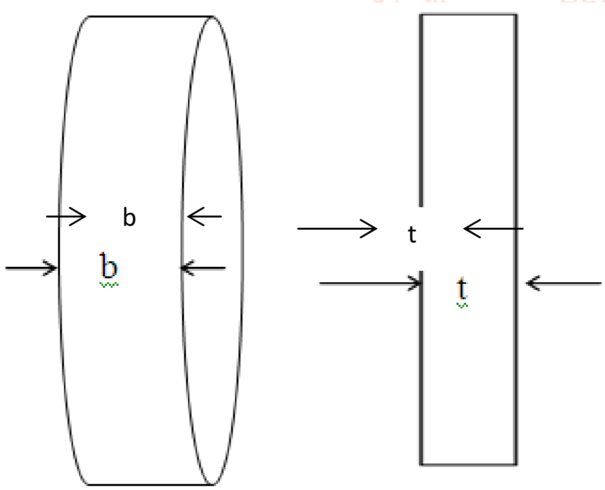

Figure7. Belt

Belt material = Convass belt

Density of belt, ρ = 1220 kg/m^3

Length of belt, L = 58.28m

Width of belt, b = 0.35 m

Thickness of belt, t = 0.01 m

Table I. Result Data for Bucket Elevator Design

Capacity, Q	70 tons/hr
Belt speed, v	1.9 m/s
Pulley diameter, d	0.6 m
Drive speed, N	60 rpm
Length of the belt, L	58.28 m
Number of buckets	350
Mass per bucket, m	1.7 kg
Torque, T	3531.6 Nm
Power, P	22 kW
Shaft diameter, d	0.073 m
Tension in the tight side, T_1	9028.075 N
Tension in the slack side, T_2	3517.89 N

VII. Discussions and Conclusion

This paper describes the functions of bucket elevator installation and operation. This conveyor is used in intake section for the industry. Required data are collected from Myanmar C.P. Livestock Company (Taunggyi Feedmill). The height of the bucket elevator is 28.8 m. The number of buckets is 350 buckets and capacity is 1.7 kg. From the calculation result, the belt speed must be 1.9 m/s, the tension on tight side is 9028.075 N and tension on the slack side is 3517.89 N. Top and bottom pulley are 0.6 m and fixed with rubber to product slip of belt. The weight acting on the shaft is 11772 N. So, the minimum shaft diameter is 0.073 m. The result of the calculation is safe for operation and design is specified. So, this conveyor can be definitely used in the industry. This conveyor can use gradually load and somewhere else. For every industry, this conveyor is safe and it can be used with trust. Bucket elevator is the best way to lift bulk material and easy to transport huge amount of bulk material.

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