The relationship of power speed and bucket elevator capacity to the slope angle of the bucket at the palm oil mill

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Abstract. The bucket elevator is material transfer equipment which function is essential in the process of processing fresh fruit bunches into palm oil, the value of effectiveness and economics is the basis for designing equipment in a factory, and bucket elevators have a certain angle. This study aims to analyze the motor power, bucket speed, and damping capacity with varying slope angle. The analysis is done by making an angle of 30,45,60,80, and 90 degrees, with as the angular variation was analyzed. Theoretically, the result shows that at the slope of 30 degrees power of the motor is 3.2 kW. The bucket speed at 6.7 m/s the damping capacity 0.00062 m^3, bucket speed of 4.6 m/s damping capacity 0.00088 m^3, at the slope of 60 degrees motor power 5.7 kW. The bucket speed of 3.8 m/s damping capacity 0.00106 m^3 at the slope of 80 degrees motor power 7.04 kW, bucket speed of 3.1 m/s damping capacity 0.00128 m^3, at the slope of 90 degrees motor power 4.9 kW, bucket speed of 4.5 m/s damping capacity 0.00098 m^3. The results above and analysis shows that the slope of the bucket angle on the elevator affects motor power bucket speed and damping capacity.

1. Introduction

Efficiency and economics are the basis of engineering. Failure in design will have an impact on reducing the overall production process performance. The Bucket elevator is material transfer equipment which function is essential in the process of processing fresh fruit bunches into palm oil. The value of effectiveness, efficiency, and economics is the basis for designing equipment in a factory, on the operation of bucket elevator moves the materials from the low level to the higher level and slope angle of the bucket has some variation. The study to be done is the impact of the slope angle of the bucket against motor power speed and damping capacity.

2. Literature Study

Bucket elevator is equipment to transfer bulk material by using belt or chain without end of those, with vertical path direction and supported by the casing of frame, bucket elevator consisting of a lead bucket arranged with a distance between the same bucket. In it, the operation consists of two work systems, namely input, and output system, as shown below.

a. Input System

The input system at bucket elevator designed generally depend on the kind of material will be transported. In general, the method used is the shoveling of material on the bucket.

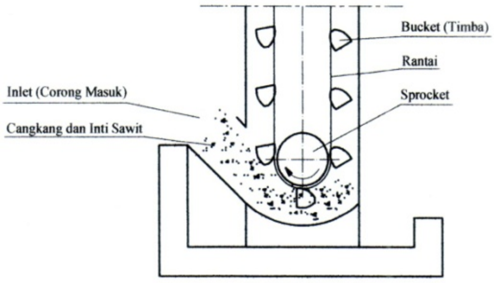


Figure 1. Input system

b. Output System

The output System at bucket elevator base on the concept of centrifuges which the material will be thrown out design, through the gravitational force of the material falling into the pan.

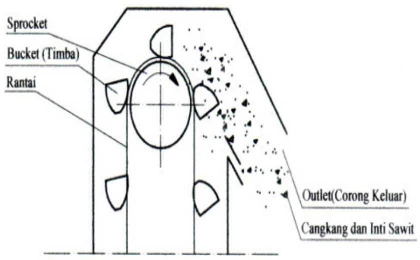


Figure 2. Output System

Special bucket elevator for transporting various materials such as powder, small particles, and bulk materials, the material are cement, sand, charcoal, flour, and others. It may lift materials at the height up to 50 meters, capacity 50 m3/h, base on transmission system bucket elevator consists of two kinds such as:

1. Using belt transmission, bucket elevator used belt we have to pay attention
   a. The material factor should be lifted, if the temperature to high (up to 150^0C), belt may get elongation until strength down.
   b. Transmission factor for transporting. If the material carries as powder, the fine powder should enter to the side one, consequently, pulley and belt get a slip.
2. Transmission by using chain something has to attention as
   a. The elongation cause of higher temperature of material relatively small.
   b. Slip at transmission system rarely occurs because using sprocket.

3. Theoretical calculation of bucket elevator

The theoretical calculation of the bucket elevator can be shown, such as:

a. The capacity of transfer (ton/h) of bucket elevator per meter length of the conveyor

$$\frac{io}{\alpha} = \frac{Q}{3{,}6.v.\gamma.\varphi} lit/m \tag{1}$$

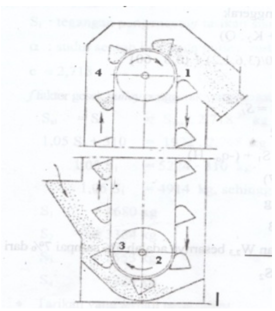
b. Velocity of bucket

$$v = \frac{Q}{Mt.K_1}. \tag{2}$$

$$Mt = \frac{mb.n}{L} \cdot \qquad (3)$$

c. Motor Power

To determine the power of the motor,firstly,calculate stress occurs at the chain.



S_{max} = 1,15 . H (q + K_2 .Q) (4)

$S_2 = S_1 + W_{1.2}$ (5)

$S_3 = S_2 + W_{3.2}$ (6)

$S_4 = S_3 + W_{3.4}$ (7)

$S_{sl} = S_4 = S_{max}$. 2,718 kg

$W_{dr} = K'(S_1 + S_4)$ (8)

$W_o = S_4 - S_1 + W_{dr}$ (9)

Figure 3. Diagram for calculation the bucket elevator

Analyses of vary angles :

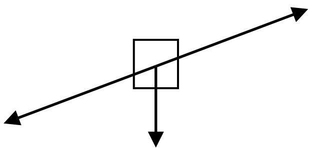


Figure 4. Diagram for calculating bucket elevator with slope angle.

S_1 the angles makes stress the chain higher, it occupied at point S_2 and S_4, then for calculating stress uses the formula :

S_2 $\quad S_2 = S_1 + W_{1.2} \sin \alpha$ (10)

W $\quad S_4 = S_3 + W_{3.4} \sin \alpha$ (11)

$W_{dr} = (W_{dr} + W\sin \alpha) + (S_4 + W\sin \alpha) + (-S_1 - W\sin \alpha)$ (12)

After knowing all stress occurs every point,then we may calculate the power.

$$N = \frac{W_o .v}{102\eta_o}. \qquad (13)$$

4. Results and Discussions

4.1. Results

The results of this study shown in figure 5 to 7.

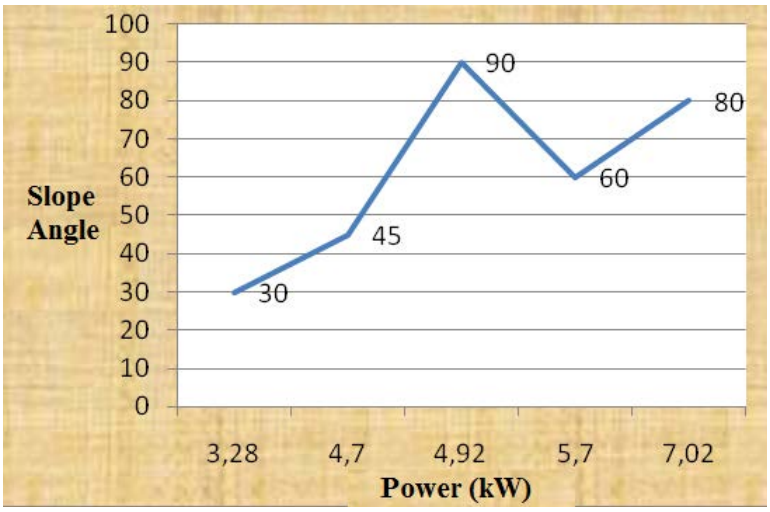


Figure 5. The slope angle of bucket elevator vs. velocity of bucket

Figure 5 shows the slope angle of bucket elevator affects the power of motor gets fluctuation, at slope angle 80^0 the power (7.04 kW), at slope angle60^0 the power (5.7 kW),at slope angle 90˚ the power (4.9 kW), at slope angle 45˚ the power (4.7 kW) and the smallest slope angel 30˚ the power (3.28 kW).

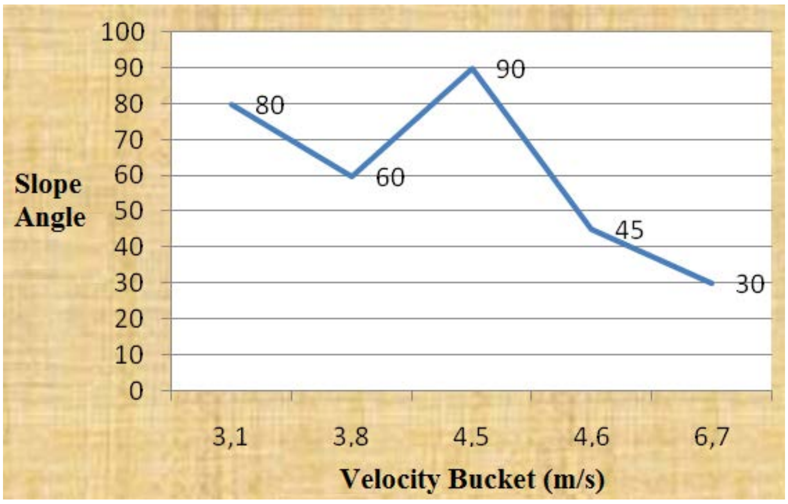


Figure 6. The slope angle of bucket vs. velocity of bucket

Different with power, relation of slope angle versus velocity of bucket shows different result which are slope angle 45^0 the velocity 4.6 m/s, slope angel 90˚ the velocity 4.5 m/s, slope angel 60˚ the velocity 3.8 m/s and the slowest velocity of bucket at slope 80˚ is 3.1 m/s.

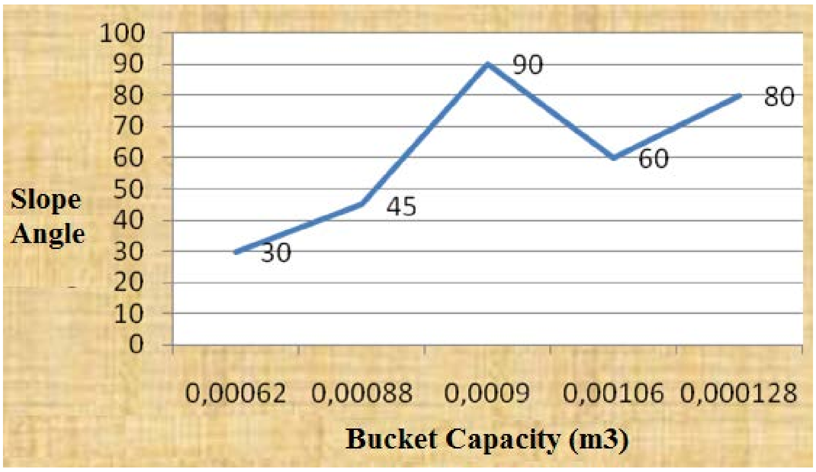


Figure 7. The slope angle of bucket vs. capacity of the bucket

Figure 7 shows the highest capacity of bucket at the slope of angel 80˚ is 0.00128 m^3, then at the slope of angle 60˚ (0.00108 m^3), at the slope of angel 90˚ (0.00090 m^3), at the slope of angel 45˚ is 0.00088 m^3, and the smallest capacity of the bucket at slope angel 30˚ is 0.00062 m^3**.**

4.2. Discussions

Base on calculation and experimental in this study may preference others company who want to design and construct the palm oil plant, which has capacity 30-ton fruit palm /hour. Table 1 shows the relationship between the slope angle of bucket and power, the velocity of the bucket, and the capacity of the bucket.

Table 1. Capacity of bucket

Slope Angle	Power (KW)	Velocity (m/s)	Capacity (m^3)
30	3.28	6.7	0.00062
45	4.7	4.6	0.00088
60	5.7	3.8	0.00106
80	7.04	3.1	0.00128
90	4.9	4.5	0.00098

Table 1 shows :

a. Higher of bucket capacity affects of the power neededbecause bucket capacity affect mass in the bucket, and $M = \rho \cdot v$

   where :

   m = mass of charge bucket

   ρ = density of material = 681 kg/m^3

   v = volume (capacity) m^3

b. Velocity of bucket

   The velocity of lift affects the capability of the elevator, which is the elevator should be operated at 30 Ton fruit palm/hour, and the relationship between velocity with a capacity of elevator is

$$v = \frac{Q}{Mt.K_1}$$

where :

V = Velocity of bucket (m/s)

Q = Capacity of Palm Oil Mill = 30 ton fp/h

K_1= scooping-up factor = 1,5

5. Conclusions

The slope of angle needed the highest power at slope angle 80^0 (7.04 KW), then at slope angle 60^0 (5.7 KW), at slope angle 90˚ (4.9 KW), at slope angle 45˚ (4.7 KW) and the smallest power occurs at slope 30˚ (3.28 KW). The slope angle at 30˚ has the highest velocity (6.7 m/s), then at slope angle 45˚ (4.6 m/s), at slope angle 90˚ (4.5 m/s), at slope angle 60˚ (3.8 m/s) and the lowest velocity occurs at slope angle 80˚ (3.1 m/s).The most significant capacity occurs at slope angle 80˚ (0.00128 m^3), then at slope angle 60˚ (0.00108 m^3), at slope angle 90˚ (0.00090 m^3), at slope angle 45˚ (0.00088 m^3), and the smallest capacity occurs at slope angle 30˚ (0.00062 m^3) The slope angle 90˚ is the most stable angle, at power of (4.9 KW) and velocity of bucket (4.5 m/s) with capacity of bucket (0.00090 m^3).

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References

[1] A. Spyvakosky, 1964, Conveyors and Related Equipment,

[2] Ferdinand P. Beer, E. Russel Johnston, Jr,1996, Mechanic for the engineer, for Edition, Erlangga, Jakarta.

[3] T.B. Sitorus et al., 2018 IOP Conf. Ser.: Mater. Sci. Eng. 420 012025.

[4] Muhib Zainuri Ach, ST, 2006, Mesin Pemindah Bahan, Edisi Pertama, CV.Andi Ofset, Yogyakarta.

[5] Rudenko N, 1992, Material Handling, Erlangga, Jakarta.

[6] T.U.H.S. Ginting Manik et al., 2018 IOP Conf. Ser.: Mater. Sci. Eng. 420 012026.

[7] Sularso, Kiyokatsu Suga, 1997, Dasar - Perencanaan Dan Pemilihan Elemen *Mesin*, Edisi Kesembilan, PT. Pradya Paramita, Jakarta

[8] Syamsir A Muin, 1990, Pesawat - Pesawat Pengangkat, Edisi Pertama, PT. Raja Grafindo Persada, Jakarta.

[9] Alfian Hamsi,2009, Studi korosi pada bucket pada pabrik kelapa sawit kapasitas pabrik 30 Ton Tbs/jam, Jurnal Dinamis Vol II No.4.

[10] J Arjuna et al. 2018 IOP Conf. Ser.: Mater. Sci. Eng. 309012088.