http://dx.doi.org/10.21172/ijiet.94.02

Effortless Water Lifting Bucket Elevator

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Abstract—In this experiment, two belt elevators equipped with buckets placed parallel with each other with intermediate gear arrangement in between them. Out of both, shorter elevator has half of length than the longer one with half number of buckets having twice or more than twice the volume as compare to longer elevator buckets. In this experiment shorter elevator has gear & pulley of twice the diameter of larger elevator. It is so synchronized that both the elevator complete the cycle in same time by some internal gearing arrangement. In every cycle of longer elevator, the buckets collect water & lifted it to discharge point & discharge on the buckets of shorter elevator. The shorter conveyor has opposite motion with respect to longer one due to weight of water collected in it. So that down word force on shorter elevator is transmitted to the longer elevator & made it to balance by few intermediate gears. So system is balanced like weighing balance measuring instrument. So one can operate the system easily by utilizing light effort just to overcome the static friction of the system.
Index Terms—Chute, Bucket, Elevator, Timing belt.

I. INTRODUCTION

Bucket elevator, also called a grain leg, is a mechanism for hauling flow able bulk materials (most often grain or fertilizer) vertically. Bucket elevators are used to handle various types of materials- abrasive, fragile, light, and heavy. Early days bucket elevators are used a flat chain with small steel buckets attached uniformly. While some elevators still are manufactured with a chain and steel buckets, most current bucket elevator construction uses a rubber belt with plastic buckets. Endless belt & pulley is driven by an electric motor. There are three common bucket elevator designs seen in bulk material handling now a days:

1) Centrifugal Discharge Elevator - The elevator buckets discharge content freely by the use of centrifugal force. Product flings out of the bucket into the discharge chute located at the top of the elevator itself [1].

2) Continuous Discharge Elevator - This type of bucket elevator is used generally to discharge sluggish and non-free flowing content where the elevator buckets discharge at top [2].

3) Positive Discharge Elevator -. This type elevator bucket equipped double strand chain where they are held in place by two pins so the bucket is allowed to freely swivel. For dischargeof product it is mechanically tripped to flip and discharge but until this action the bucket is held parallel to the floor and remain upright [3].

Looking at the above feature, the experiment is indent to make effortless for water lifting by using two bucket elevator side by side. II.

II. MATERIALS AND METHODS

This set up consist of two bucket elevator shown in Figure 1, and the elevator to lift water from well having smaller special designed buckets (oblique cut face) arranged in all around the elevator belt, where as other elevator having half of length compared to previous one with special designed buckets (oblique cut face with twice the diameter of previous one) all over the belt. Both of elevators placed parallel to each other on channeled structure as shown in Figure 2. If one of them rotated in clock wise then other will rotate in antilock wise to complete the cycle & cycle time for operation is same for both the both elevator.

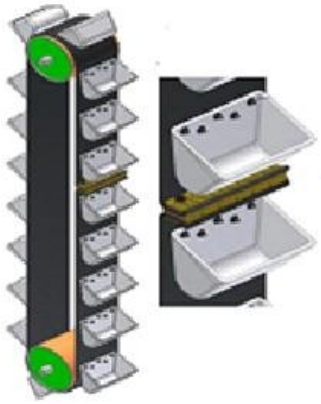

Fig. 1. Bucket elevator system

Both the elevator interconnected with each other through intermediate spur gears & all gears have same pitch circle & module but whereas smaller elevator accommodate larger gear of diameter twice as compared to other & same module. The experiment set up of the bucket elevator is shown in Figure 3. These series of gears consist of gear train which transmits force& power from one another vice versa. Generally gears are mounted at the end of each pulley mounted shaft is known as driving gear and driven spur gears are mounted on mid-way of the separate shaft arranged in one plane at the top of set up. In this set i.e., in the water lifting elevator bucket faces are arranged in the direction of motion, whereas the bucket faces are arranged in opposite side of motion of conveyor in shorter adjacent elevator.
In this set up, buckets of lifting elevator is half the size of adjacent conveyor and total number of buckets in water lifting elevator is twice the number of bucket located in shorter elevator.
Both the elevator are so placed side by side so that tops are located in same level so elevator pulley ,driving, and intermediate gears are arranged in same level.

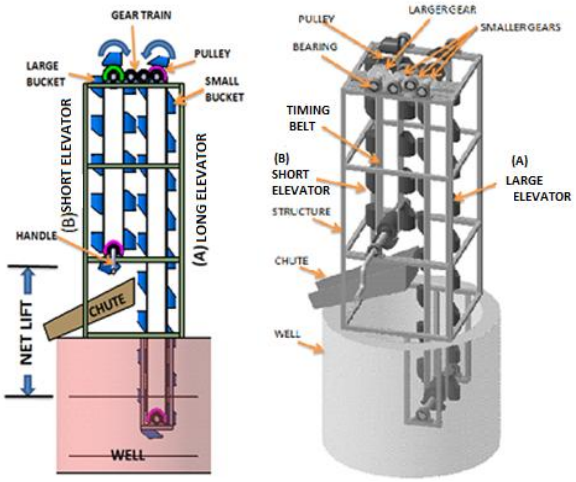

Fig. 2. Bucket elevator on channeled system

But hanging bottom portion of the water lifting elevator dipped into water inside the well for lifting of water, whereas bottom portion of smaller elevator seat on the platform above the well. In this set up water will be lifted to top and drained out water to the other elevator ,so water content remain same in both the elevator, so upward force required to lift the bucket filled water longer one is same as down ward force experienced by water on the smaller elevator .

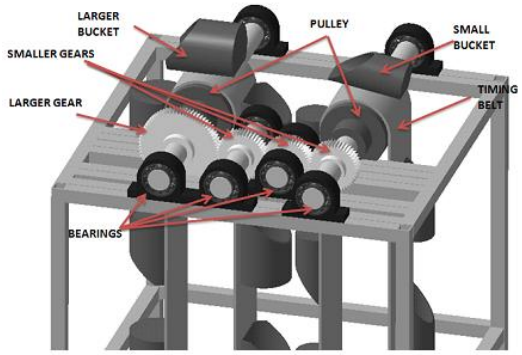

Fig. 3. Experimental Set up of bucket elevator

So down ward movement tendency or force due to self-weight of water on buckets in smaller elevator will exerts same force on spur gear of larger conveyor through gear train arrangement as shown in Figure 4. Since both the conveyor handled same quality of water at any instance of cycle, so system is balanced at every position as lifting force required is same as down ward force experienced by water filled bucket in shorter elevator. So it is clear from above there is no net resultant force experienced by water filled bucket on both the elevator mechanism.

As a whole we can compare this arrangement with balance weight measuring instrument with equal weight on both side & if we put a small weight in any side then other side will lifted up automatically. As a whole this system has experienced some sorts of static friction between gear to gear, pulleys to belt. So little force is required to overcome this static friction and then it is easy to rotate the system [3]. So a small handle is mounted for operation that can be operated by leg or hand by operator to resume the operation.

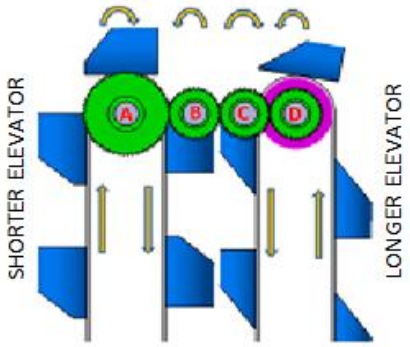

Fig. 4. Gear Train Arrangement

Bucket design: Water lifting buckets are simple & opening is simple oblong cut, where water lowering Buckets are designed to reduce wastage of water. Here several chutes or funnels are attached to the side of bucket to direct water to collect in successive lower bucket as water strike on side wall of bucket & water poured directly into the mouth of lower lowering bucket when water lifting bucket directed into the said bucket.[4]-[5].Water lowering buckets are more than twice the size of water lifting bucket [6]. The bucket design is shown in Figure 5.

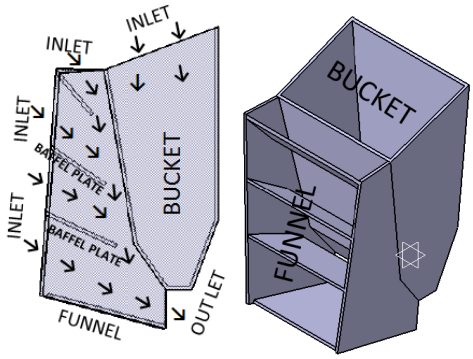

Fig. 5. Bucket Design of the elevator

Advantages:

- Very less effort is required by foot or hand.
- No electric motor is required.
- No noise pollution.
- No chemical (liquid or gas) contamination takes place.
- Maintenance cost is negligible.
- Transportation to other place is easy by dismantling the system.
- Net lift can be increased or decreased as height increased.
- It is indirect way of doing body exercise.
- Effect will prominent as height increased

Disadvantages:

- One time investment.
- Require more floor area.
- Net lift is slightly smaller or equal to half of the length of lifting elevator.
- Initially it require high effort
- Static friction cannot be avoided

III. EXPERIMENT AND RESULT

As per design conveyor-A has larger gear of twice pitch circle diameter elevator -D gear.
In gear train circular pitch of each gear is same.

So $\pi\frac{D_A}{T_A} = \pi\frac{D_B}{T_B} = \pi\frac{D_C}{T_C} = \pi\frac{D_D}{T_D}$ OR $\frac{D_A}{T_A} = \frac{D_D}{T_D}$

OR $\frac{D_A}{D_D} = \frac{T_A}{T_D}$ (1)

As Circular pitch, $P_c = \frac{\pi D}{T}$

where D = Dia of pitch circle in mm &T= Number of teeth

We know that speed ratio

$\frac{N_A}{N_D} = \frac{T_D}{T_A} = \frac{1}{2}$ (2)

$N_A = 2N_D \,\&\, 2T_D = T_A$ (3)

As per above free body diagram(Figure.6), FR acts radially towards the center of each individual gear & F_T acts opposite to motion of driving gear .

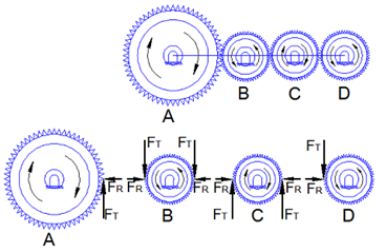

Fig. 6. Free body diagram of force

So as per our setup gear A is driving gear hence FT act upward & downward adjacent side of gear B at meeting point likewise in gear D ,F_T acts down ward. Since F_T is equal &opposite in gear D & gear A, So that force required to lift water in longer elevator is same as that the force exerted by collected water in shorter elevator. Suppose pulley center distance of longer elevator is 2mts or 200cm is shown in Figure 7. Whereas the short elevator length is 1mt or100cms.

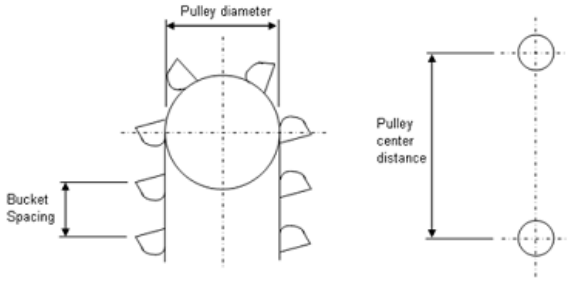

Fig. 7. Pulley diameter of the system

Diameter of longer elevator pulley = 10cms

Longer elevator has got belt length, = $\pi D + (2x200) = \pi\, 10 + (2x200) = 431.5cm$

Suppose Longer elevator equipped with buckets say about 16 no's of size half liter.

Bucket spacing on longest elevator belt = $\frac{431.5}{16} = 26.9 \approx 27cm$

Shorter elevator has got belt length, =Half of longer one

$= \frac{431.5}{2} = 215.75$ cm

Diameter of shorter elevator pulley = 20cms

Shorter elevator equipped with buckets say about 08 nos of size one liter.

Bucket spacing on shorter elevator belt = $\frac{215.75}{8} = 26.9 \approx 27\ cm$

So here Net lift is= (total height of longest elevator – total height of shorter elevator

$= \left\{(D + 200) - \left(\frac{215.75 - \pi d}{2} + d\right)\right\}$

$= \left\{(10 + 200) - \left(\frac{215.75 - 62.8}{2} + 20\right)\right\}$

$= \{210 - (76.47 + 20)\} = 113.5\text{cm}$

Force experienced on individual buckets against gravity,

$= mg = \frac{1}{2}\text{Kg x } 9.81\frac{m}{s^2} = 4.905\text{ N}$

So, force experienced by 08nos of buckets of size ½ liter on longer elevator

$\text{FORCE(W)} = mg = 8\text{ x}\left(0.5\text{Kg x}9.8\frac{m}{s^2}\text{x2mt}\right) = 39.2\text{mt}$

Virtual work done by lifting successive 08 buckets up to 02 mt

$\text{WORK(W)} = 8\text{x}\left(0.5\text{Kgx}9.8\frac{m}{s^2}\text{x2mt}\right) = 78.4\text{Nm}$

So, force experienced by 04 nosof buckets of size 01 liter on shorter elevator

$\text{FORCE(W)} = mg = 04\text{x}01\text{Kgh x } 9.8\frac{m}{s^2} = 39.2\text{N}$

Virtual work done by lowering successive 04 buckets up to 01mt

$\text{WORK(W)} = 4x\left(1\text{Kgx}9.8\frac{m}{s^2}\text{x1mt}\right) = 39.2\text{Nm}$

Bucket Elevator Power Formula:

Equation Symbols

$P = \frac{WXH}{T} + C$

Where P: Power required to convey the water; W: Weight of water being lifted; H: Lift height; T:Time; and C: HP required to overcome the friction in the system

The Friction Factor method uses a multiplication factor of account for the friction in the system.

Friction includes the following variables:

- Bucket pouring
- Belt slip on the head pulley in case of flat belt
- Bearing friction
- Gear drive transmission friction
- Drive Inefficiencies

Factor "C" is an estimate of the friction in the system and is required to accurately determine the power requirements of a Bucket Elevator

Calculation

Total no of buckets 16 Nos

Bucket spacing 270 mm or 0.27mt

Pulley diameter, $D = 2R = 2\frac{V^2}{g}$

Suppose pulley diameter = 10 cm

$= 0.1m = 2\frac{V^2}{g}\left[\because F_C = F_g \Rightarrow MV^2 = Mg \Rightarrow D = 2\frac{V^2}{g}\right]$ (4)

= V = 0.7 m/s

Belt speed 0.7 m/s

Removal rate = 3x0.27 mts = 0.8 m/s Bucket speed = 0.8 m/s

Material path:

$S = ut + \frac{1}{2}a\,t^2$ (5)

Where,

S = Displacement (mts)

u = Initial velocity (m/s)

a = acceleration (m/s^2) = 9.8 m/s^2

t = time in seconds

$\left\{ut = S_h\ , S_v = \frac{1}{2}at^2\right\}$

Trajectory after the product leaves the bucket can be graphed and the chute height determined. Table 1 shows the time versus the distance.

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Table1: Time vs. Distance

TIME(s)	S_h(mm)	S_v(mm)
0.1	80	49
0.2	160	196
0.3	240	441
0.4	320	784
0.5	400	1225

The horizontal component at top dead centre of the pulley where acceleration due to gravity in the horizontal direction is zero is given by S_h=vt.Meters.

The vertical component at top dead centre where velocity in the vertical direction is zero is given by S_V= 0.5x1/2 at^2meters.

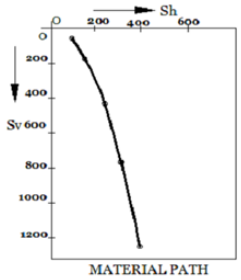

Fig. 9. Material path versus distance travelled

From the table-1 it is noted that after 0.2 seconds of flight the product has traveled 160 mm horizontally from top dead center and 196 mm vertically. The pulley radius is 50mm which means the product is clear of the pulley by 110mm.So water collected in longer conveyor is very easily discharged in shorter elevator. Here shorter conveyor bucket diameter size is twice than longer bucket diameter size.

IV. CONCLUSION

It is more advantages for agriculture purpose. Beside at the starting condition it requires more effort to fill water in one side of the elevator buckets of both individual. But after this it is smoother to operate by human being continuously by giving slight more effort to overcome static friction of equipment.

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